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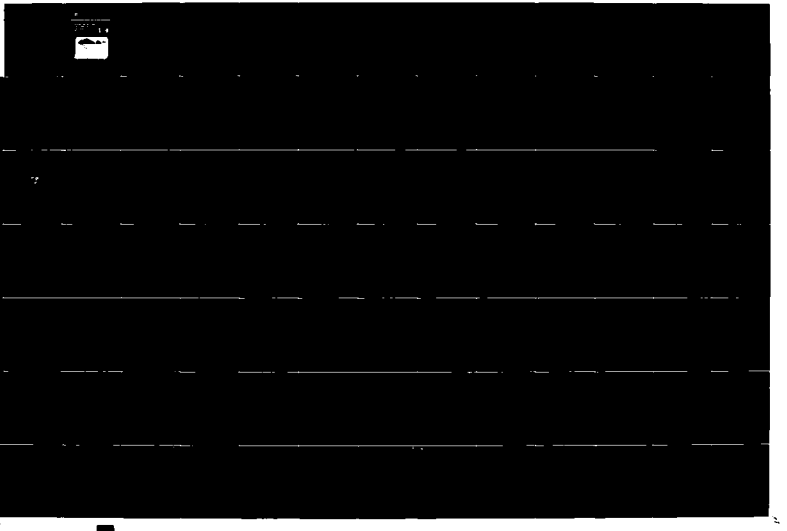

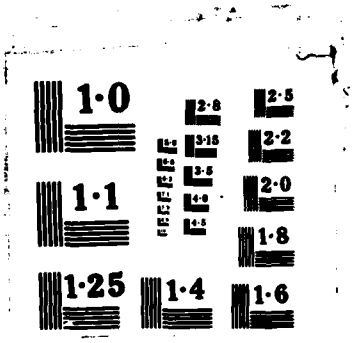
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US Army Corps of Engineers
Los Angeles District

COAST OF CALIFORNIA
STORM AND TIDAL WAVES STUDY

SHORELINE MOVEMENT DATA REPORT

PORTUGUESE POINT TO MEXICAN BORDER

(1852 - 1982)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THIS REPORT PRESENTS THE RESULTS OF A COOPERATIVE STUDY OF SHORELINE MOVEMENT CONDUCTED BY THE NATIONAL OCEAN SURVEY (NOS) OF NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA), AND THE US ARMY CORPS OF ENGINEERS WATERWAYS EXPERIMENT STATION (WES) AND COASTAL ENGINEERING RESEARCH CENTER (CERC). THE STUDY AREA COMPRISED THE PACIFIC OCEAN COAST FROM PORTUGUESE POINT, CALIFORNIA (NEAR LOS ANGELES) SOUTH TO THE UNITED STATES/ MEXICO BORDER. SURVEY DATA FROM NOS AND ITS PREDECESSOR, THE US COAST AND GEODETIC SURVEY (C&GS) ARE USED TO ANALYZE SHORELINE POSITION CHANGES RANGING FROM

FROM AS EARLY AS 1852 OR AS LATE AS 1959, UP TO 1982.

THIS REPORT IS DESIGNED PRIMARILY TO DESCRIBE AND QUANTIFY SHORELINE MOVEMENT MAPS (PRODUCED BY NOS) THAT ACCOMPANY IT. AVERAGE YEARLY LAND AREA AND SHORELINE MOVEMENT RATES OF CHANGE ARE CALCULATED FOR EACH MINUTE OF LONGITUDE FOR THE AREA FROM PORTUGUESE POINT SOUTH TO ANAHEIM BAY (EAST-WEST TRENDING SHORELINE) AND FOR EACH MINUTE OF LATITUDE FROM ANAHEIM BAY TO THE US/MEXICO BORDER (NORTH-SOUTH TRENDING SHORELINE) AND SPATIAL VARIATIONS (SHORELINE MOVEMENT) FOR EACH MINUTE OF THE OCEAN/LAND INTERFACE EXCEPT FOR HARBOR AREAS. HARBOR AREAS WERE NOT ANALYZED BECAUSE SHORELINE CHANGES THERE ARE USUALLY AN INSEPARABLE MIX OF MAN-MADE AND NATURAL EVENTS.

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SHORELINE MOVEMENT DATA REPORT
PORTUGUESE POINT (LOS ANGELES COUNTY) TO MEXICAN BORDER
(1852-1982)
Ref. No. CCSTWS 85-10

Coast of California Storm and Tidal Waves Study

U.S. Army Corps of Engineers
Los Angeles District, Planning Division
Coastal Resources Branch
P.O. Box 2711
Los Angeles, California 90053

DECEMBER 1985

prepared by

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
Vicksburg, Mississippi

SHORELINE MOVEMENT DATA REPORT: PORTUGUESE POINT, CALIFORNIA TO THE MEXICAN BORDER (1852-1982)

PREFACE

This report is the result of a cooperative effort of the National Ocean Service (NOS), National Oceanic and Atmospheric Admisistration, U.S. Department of Commerce, the U.S. Army Engineer District, Los Angeles, and the Coastal Engineering Research Center (CERC) of the U.S. Army Engineer Waterways Experiment Station (WES). The study, based on a comparison of historic survey data contained in the archives of NOS, was funded jointly by the Office, Chief of Engineers, and the National Oceanic and Atmospheric Administration. All survey data reduction and quality control were performed by NOS; data analysis and report preparation were performed by CERC.

The report was prepared by Mr. Paul F. May, CERC, and Mr. Brian M. Baldwin, NOS. The work was carried out under the general supervision of Mr. Thomas W. Richardson, Chief, Coastal Structures and Evaluation Branch, CERC, Dr. William Wood, Chief, Engineering Development Division, CERC, Dr. Robert W. Whalin, Chief, CERC, and U.S. Army Engineer District, Los Angeles. At CERC, Mr. Mark Hansen assisted in development of a computer program to analyze the shoreline movement and land area change data. Mr. Darryl Bishop, Ms. Carolyn Dungan, and Ms. Debra Rouse reduced the data.

The Commander and Directors of WES during preparation of this report were COL Robert C. Lee, CE, COL Alan F. Grum. Technical Directors of WES were Mr. F. R. Brown, and Dr. Robert W. Whalin.

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PORTUGUESE POINT, CALIFORNIA TO THE MEXICAN BORDER (1852-1982)

PART I: INTRODUCTION

1. This report describes the results of a cooperative study of shoreline movement conducted by the National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Army Corps of Engineers Waterways Experiment Station Coastal Engineering Research Center (CERC). The study was performed for and funded by the U.S. Army Engineer District, Los Angeles, as part of the Coast of California Storm and Tidal Waves Study (CCSTWS). The study area comprised the Pacific Ocean coast from Portuguese Point, California (near Los Angeles) south to the United States/Mexico border, a distance of approximately 125 miles. Changes in shoreline position ranging from as early as 1852 or as late as 1959, up to 1982, are analyzed using survey data from NOS and its predecessor, the U.S. Coast and Geodetic Survey (C&GS). A series of shoreline movement maps for this coastal reach produced by NOS is intended to accompany this report. Figure 1 is an index to this map series.

2. Shoreline movements are presented covering the longest periods of historic survey record available for various portions of the study area. The maximum period of record ranges from 1959-1982 for the northern portion to 1852-1982, for the south. The longer data span (130 years) allows a more extended analysis of temporal variations in shoreline movement rates. Areas with short data spans may exhibit movement not truly reflective of long-term trends (Hayden, et. al., 1979).

3. This report provides a basic data set for use in management and engineering decisions related to the coastal zone. Historic shoreline movements are often used for predicting future change, however, extrapolation

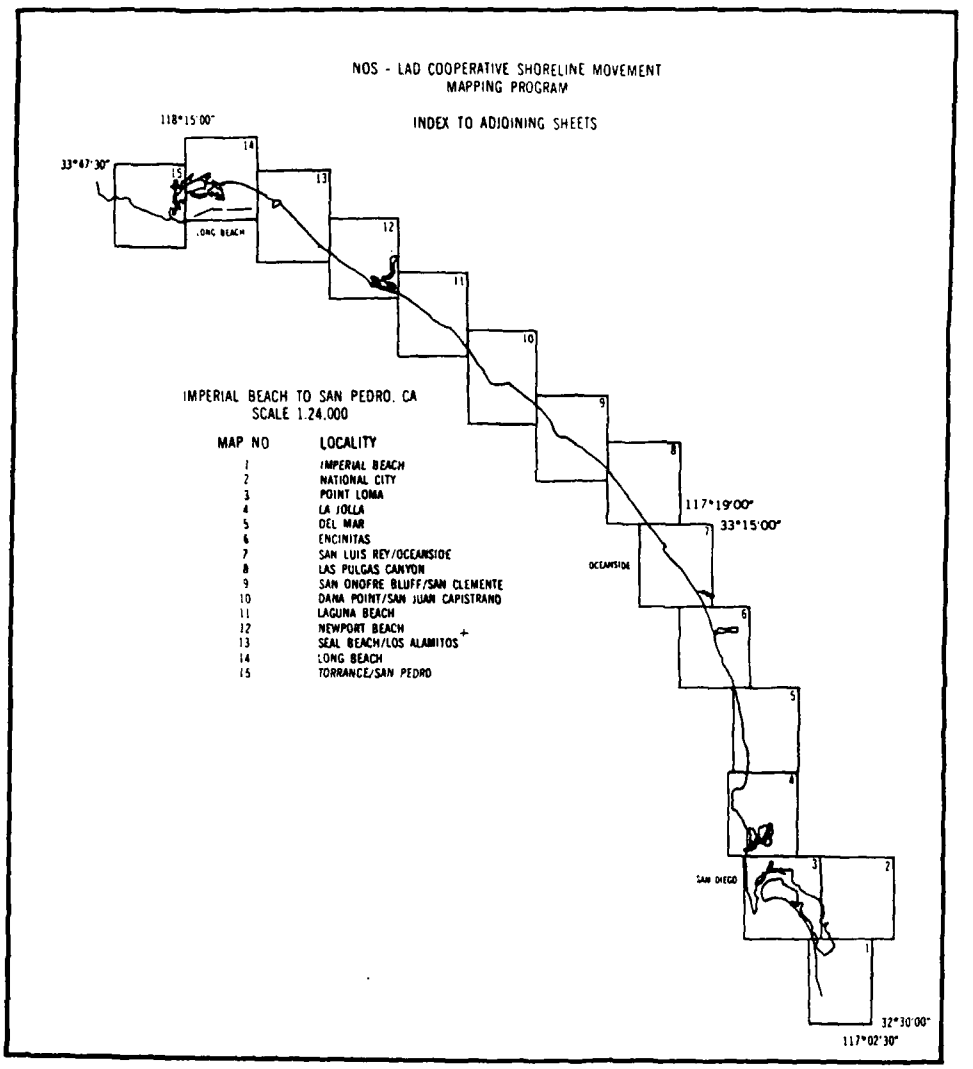

Figure 1. Shoreline movement map index (Portugese Point, California to the U.S./Mexico Border)

of past movement must be done with caution. Man's action may have affected natural coastal processes and altered the rates or even directions of movement. For example Kuhn and Shephard (1980) describe recent changes in the southern California coast attributed to human intervention. In addition to man's action, the natural processes themselves may have altered enough to significantly affect shoreline movement trends.

4. This report is designed primarily to describe and partially quantify shoreline movement maps that accompany it. Average yearly land area and shoreline movement rates of change were calculated for each minute of longitude for the area from Portuguese Point south to Anaheim Bay (east-west-trending shoreline), and for each minute of latitude from Anaheim Bay to the U.S./Mexico border (north-south trending shoreline). Standard deviations for each average were also computed and provide important information of temporal (land mass change) and spatial (shoreline movement) variations for each minute of the ocean/land interface except for harbor areas. Harbor areas were not analyzed because changes there are usually an inseparable mix of man-made and natural events.

5. The sole purpose of this report is to describe and quantify historic shoreline movement. No attempts were made to identify or even speculate on the reasons for these movements. Some apparent trends may be related largely to surveyor error; these are addressed later in the report. Comprehensive investigation of factors such as meterologic, geologic, and tectonic trends along with man's influence, is needed to assess possible reasons for the shoreline movements identified in this report.

PART II. STUDY AREA

Geographical Setting

6. The study area encompasses 125 miles of Pacific Ocean coastline. It begins in the north at Portuguese Point (2.5 mi north of Los Angeles Harbor) and extends south to the U.S./Mexico border. This coastal reach exhibits a wide range of geomorphic features ranging from rocky headlands with cliffs and small pocket beaches to wide, sandy beaches with relatively low relief. The wave climate is moderate, due to protection from Point Conception and several large islands. However, winter storms can generate waves that penetrate the islands with sufficient energy to erode local beaches. The continental shelf is approximately 10 miles wide at San Pedro Bay, but narrows to less than two miles at other locations to the north and south. The following brief area descriptions were extracted from the National Shoreline Study California Regional Inventory (1971) and the Assessment and Atlas of Shoreline Erosion along the California Coast:

Portuguese Point to the Santa Ana River

7. Portuguese Point to the San Pedro Breakwater is composed of rocky headlands and small pocket beaches. The area from San Pedro south to the Santa Ana River (25 mi) is a long stretch of low coast that forms the Los Angeles Basin. This reach has narrow-to-wide sandy beaches backed by dunes, low bluffs and seawalls.

Newport Beach to Dana Point Harbor

8. Newport Beach has wide sandy beaches which persist to the south and become narrow at Corona del Mar. From this point south to Dana Point Harbor, the coastline exhibits a range of narrow sandy and rocky beaches which are backed by bluffs. This area also has occasional low rock protrusions which act as natural groins.

Capistrano Beach to the San Luis Rey River

9. Capistrano Beach has wide sandy beaches and low dunes to the northwest. The beach becomes narrow to the south where it is backed by high coastal bluffs. The latter condition persists south to San Onofre Creek where the beach widens. South of the San Onofre Nuclear Power Plant to Las Flores Creek, the beaches once again narrow and are backed by wave cut bluffs. The beaches widen south of Las Flores Creek as the bluffs disappear near the San Luis Rey River area.

Oceanside to La Jolla Bay

10. This area has narrow sandy beaches for the most part backed by high bluffs and sea cut cliffs. Several areas - Oceanside, north of Batiquitos Lagoon, and north of Solona Beach - have sand and cobble beaches. Absence of the bluffs and sea cliffs occurs at lagoon and river flood plains.

Point La Jolla To Point Loma

11. Narrow sand and cobble pocket beaches with frequent seacaves and eroding cliffs exist in the Point La Jolla area. The beaches become sand and wide with relatively low relief in the Mission Beach area. Ocean Beach to Point Loma is characterized by high, nearly vertical, rocky cliffs with narrow pocket beaches, numerous sea caves and coves. Landslides occur along much of this reach. Point Loma rises to its highest (400 ft) near the southern tip. High vertical cliffs exist on both sides of this feature.

North Island to the U.S./Mexico Border

12. This area includes San Diego Harbor, the only natural harbor in southern California, and is characterized by sandy beaches backed by low dunes or seawall. Beach width alternates from wide to narrow. South of Imperial Beach, the beach becomes cobble and sand backed by marsh, sloughs, and river flood plain along the Tijuana River or Estuary.

PART III. DATA COMPILATION AND REDUCTION

Data Sources

13. Twenty U.S. Geological Survey (USGS) quadrangle maps (1:24,000 scale) were selected to provide the base maps for this project. Because only the shoreline was of importance to this map series, the total number of maps needed to effectively cover the coastal area was reduced to fifteen. Appendix A explains which data were used as the base for each map.

14. NOS has on file 127 suitable shoreline surveys and maps for the study area, at scales ranging from 1:5,000 to 1:20,000 and dating from 1851 through 1974. Practically all of the earliest surveys were topographic plane table surveys. From 1972 on the surveyors used photogrammetric methods increasingly to provide topographic information.

15. The most recent survey data (1982) was derived from six flight lines of natural color aerial photography taken at 1:40,000-scale over the project area. Four lines were photographed on March 20, 1982, at a tide stage of +0.1 ft above mean lower low water. These lines covered the area from San Diego to Torrance, California. The other two lines were photographed on November 25, 1982, at a tide stage of +2.5 ft above mean lower low water. These lines covered the area from Point Vincente to Long Beach, California. Twenty of the photographs from these six lines were enlarged to 1:24,000 scale and used to compile the 1982 shoreline used in this report.

Shoreline Definition

16. Topographic surveys have been compiled by NOS since the early 1800's in support of hydrographic surveys. They are the basis for delineating the shoreline on nautical charts published by that agency. Shalowitz (1964), the authoritative source on the historical significance of early topographic surveys of NOS, notes: "The most important feature on a topographic survey is the high water line." High water line (HWL) is a general term; because it is the shoreline used in this report, it is important to define the line as actually surveyed through the years by NOS and its predecessor agencies.

17. About 1840, Ferdinand Hassler, the first Superintendent of the Survey, issued the earliest instructions for topographic work. Included in these instructions (Volume 17, Coast Survey, Scientific, 1844-1846, handwritten) is the following:

"On the sea shore and the rivers subject to the tides, the high and low water lines are to be surveyed accurately; and the kind of ground contained between them, whether sand, rock, shingle or mud marked accordingly. The low water line is taken by offsets whilst running the high water, and when not too far apart from each other, but when their distance is great they must be surveyed separately: a couple of hours before the end of the ebb, the same time during the commencement of the flood tides will be the proper time for taking the low water line, and your operations must be so timed, as to be on the shore on those periods.

You will establish points along the shores, and mark them securely by means of stakes, at suitable distances, for the use of the hydrographical parties in taking their sounding - and also furnish them with the high and low water line, from your map, they may require."

18. The first specific instruction regarding the nature of the line to be surveyed is contained in the Plane Table Manual (Wainwright, 1898). It states:

"In tracing the shoreline on an exposed sandy coast, care should be taken to discriminate between the average high water line and the storm water line."

19. Shalowitz (1964) elaborated by stating:

"The mean high water line along the coast is the intersection of the plane of mean high water with the shore. This line, particularly along gently sloping beaches, can only be determined with precision by running spirit levels along the coast. Obviously, for charting purposes, such precise methods would not be justified, hence, the line is determined more from the physical appearance of the beach. What the topographer actually delineates are the markings left on the beach by the last preceeding high water, barring the drift cast up by storm tides. If only one line of drift exists, as when a higher tide follows a lower one, the markings left by the lower one would be obliterated by the higher tide and the tendency would be to delineate the line left by the latter, or possibly a line slightly seaward of such drift line.

In addition to the above, the topographer, who is an expert in his field, familiarizes himself with the tide in the area, and notes the characteristics of the beach as to the relative compactness of the sand (the sand back of the high water line is usually less compact and coarser), the difference in character and color of the sun cracks on mud flats, the discoloration of the grass on marshy areas, and the tuffs of grass or other vegetation likely along the high water line."

20. The preceding references emphasize the intention of all these topographic surveys to determine the mean high water for delineation on maps. With the exception of tidal marsh areas, where in most cases the outer

vegetation limit was surveyed, the mean high water line shown on a map is the line at the time of survey or on the date of photography.

21. With the advent of precision aerial photography, compilation of "T-sheets" entered a new dimension. The mean high water line can now be determined accurately from such photographs with stereoscopic instruments and known tide data. This method is, when possible, verified by profile points run from vertical bench marks. When profiles are run as part of contemporary surveys, they are referenced to the nearest primary tide station.

1982 Mean High Water Line

22. To make this study as current as possible, USGS quadrangles and other selected maps were revised to show a 1982 mean high water line. The revision was made by the Special Projects Unit of the NOS Photogrammetry Branch using the color aerial photographs described in paragraph 15 and the general methods described in paragraph 21. Due to funding constraints, the office-determined 1982 mean high water line was not field checked, but it was reviewed to assure uniform accuracy in photo interpretation. The 1982 maps were also digitized, checked and reviewed in the same manner as all other historical source maps.

Historical Maps

23. Over 165 historical maps were checked for possible use in this project. Approximately 25 percent were rejected for the following general reasons: 1) the map scale was incompatible with the accuracy needed, and the area was covered by other maps at better scales, 2) the map base was distorted and it would have been impossible to remove the distortion from the reduced copy, or 3) a common datum between the map in question and the remainder of the area maps could not be determined.

24. Copies of the 127 maps chosen for this study were obtained from the NOS vault in Riverdale, Maryland. These copies initially were bromide prints (a photographic process which provides a long shelf life) and were later transferred to matte-finish film positives, which dimensionally are more stable. The chosen maps were reduced by copy camera from their original scale to a common 1:24,000 scale on .004 mm stable base Mylar. At this scale the possible map error represents a ground distance of approximately $\pm$ 39.5 ft. Map error is a combination of errors from photogrammetric reproduction and printing. Photogrammetric errors result from the inability to correct for non-linear and differential shrinkage in the original survey maps, caused by a map's cloth backing shrinking more in one direction or in one section than another. Printing errors usually result from slight misalignments on the map printing press.

25. The accompanying shoreline movement maps were produced in the following manner:

a. Fifteen base manuscripts derived from USGS 1:24,000 scale quadrangles were scribed with projections and grids by a Coradi automatic plotting instrument.

b. Fifteen film positives of the scribed projections were made and registered.

c. The fifteen registered film positives were used as bases for the map series. The 127 1:24,000 photo-reduced scale data were registered with the bases and transfered to scribe cotes These cotes consisted of a bi-layer film (clear top and translucent color top) which when scribed through the top layer produces a film positive. One sheet of scribe cote was used for each film positive for each historical survey year or period.

d. The most recent shoreline was compiled on either the USGS quads or the

latest NOS topographic survey sheets as explained earlier. These data were then transferred to scribe cotes containing Coradi-generated projections.

e. A separately registered Mylar sheet was used to depict geographic and legend information for each film positive.

f. All registered sheets (the most recent shoreline scribe cotes with projections, the historical scribe cotes, and the geographic and legend sheets) were sent to the NOS Reproduction Division for printing proof copies.

g. After checking the proof copies and applying any corrections, the project was sent to the Reproduction Division for final printing.

26. During the compilation of these maps, a major concern was minimizing datum errors by being able to project all the historical charts using the 1927 North American Datum. All charts compiled later than 1927 had the correct datum, and most of the pre-1927 charts had adjusted 1927 datums from previous projects. If no method could be used to adjust an uncorrected chart well enough to satisfy accuracy requirements, the chart was not used.

27. Other sources of potential error were also considered. The most difficult of these to quantify is the location accuracy of the MHWL on source surveys and maps. This error source may be separated into two categories: (1) the earliest surveys, prior to approximately 1930, and (2) the group of maps based on photogrammetric surveys. In discussing the first group, the early surveys, Shalowitz (1964) stated:

"The accuracy of the surveyed line here considered is that resulting from the methods used in locating the line at the time of survey. It is difficult to make any absolute estimates as to the accuracy of the early topographic surveys of the Bureau. In general, the officers who executed these surveys used extreme care in their work. The accuracy was of course limited by the amount of control that was available in the area."

"With the methods used, and assuming the normal control, it was possible to measure distances with an accuracy of 1 meter (Annual Report, U.S. Coast and Geodetic Survey 192 (1880)) while the position of the planetable could be determined within 2 or 3 meters of its true position. To this must be added the error due to the identification of the actual mean high water line on the ground, which may approximate 3 to 4 meters. It may therefore be assumed that the accuracy of location of the high water line on the early surveys is within a maximum error of 10 meters and may possibly be much more accurate than this. This is the accuracy of the actual rodded points along the shore and does not include errors resulting from sketching between points. The latter may, in some cases, amount to as much as 10 meters, particularly where small indentations are not visible to the topographer at the planetable."

"The accuracy of the high water line on early topographic surveys of the Bureau was thus dependent upon a combination of factors, in addition to the personal equatation (experience) of the individual topographer. But no large errors were allowed to accumulate. By means of the triangulation control, a constant check was kept on the overall accuracy of the work." However, shoreline position for the study area in one year may vary as much as 100 ft between winter and summer (U.S. Army, 1985). Since the early surveys took months, and in a few cases years, to complete, the surveyed mean high water lines for this study are probably non-uniform. For example, if a summer beach was surveyed for an earlier date and compared to a later winter beach, the difference might be as much as 100 ft due to seasonal variations in addition to the longer term trends of concern to this study.

28. Using aerial photographs, the MHWL can usually be located to within 0.5 mm at map scale . This translates to 16.5 ft on the ground for a map scale of 1:10,000 or 10 meters on the ground for a map scale of 1:20,000.

Since the great majority of source maps were at a larger scale than the 1:24,000 base maps, the 0.5 mm map scale accuracy was at least maintained by reducing most of the source maps to the common base scale of 1:24,000. As an example, in a recent Florida shoreline mapping project using NOS manuscripts, the locations of 36 references such as road intersections and shoreline features were scaled from a map compiled from aerial photography. These references were then surveyed by field traverse, revealing a maximum location error of $\pm$ 10 ft. This accuracy is not claimed for all cases but does serve as an indicator of the mapping accuracy attainable by standard NOS methods.

29. In the interest of clarity and neatness, if any pier, jetty, groin, or other man-made feature was located on a number of surveys, it was only depicted on the shoreline movement maps for the last survey in which it appeared. The reasons for this is that such features sometimes appear in slightly different locations, orientations, or configurations in different surveys. Since it would be impossible to determine whether these differences were due to cartographic interpretation (for instance, mapping the perimeter of a rubble-mound structure), changes in the feature itself, or other causes, the most recent representation was selected as a standard for this project.

PART IV: DATA ANALYSIS

Data Extraction

30. The accompanying maps are useful in a qualitative way; i.e., they provide an easy means of visualizing past changes. As discussed previously, the maps themselves represent a compilation of historical surveys and may include inaccuracies in the original data or other errors, such as those due to the printing process or changes in the map paper. For this reason, the accompanying maps should not be digitized for general or site specific quantitative shoreline change information. The following paragraphs describe techniques used in this study by the Coastal Engineering Research Center to enable the data that these maps depict to be used quantitatively.

31. An analysis routine was used to average shoreline change rate parameters for specified longshore distances. One-minute units of latitude or longitude (depending on shoreline orientation) were used as a reasonable and easily definable base to key all measurements. Each unit was analyzed to derive shoreline change rates for desired time periods. It deserves mention that the rates given are averages for the entire shoreline within a one-minute coastal unit, not for discrete points one-minute apart. This distinction is an important one, because measurements made at a constant alongshore interval seem to be subject to bias depending upon the particular interval chosen (Hayden, et al. 1979).

32. Areal information was extracted in addition to the shoreline change rates to establish average rates of change in land area bordering the ocean. As with the shoreline change, this analysis was keyed on 1-minute-latitude or longitude cells, depending on the average shoreline over the historical record. This analysis complements the spatial shoreline change rates by denoting the change in land area over time. A small standard deviation

indicates a uniform rate of change over the time period, while a large value indicates variability.

Analysis Methodology

33. Shoreline change rates which are averages in space, are based on the intersection of the historical shorelines with fixed transect lines in time. No attempt is made to identify what happened to the shoreline between surveys; the analysis simply distributes the change uniformly over that time interval. Shoreline movement rates were obtained by averaging the mean rates of change for all transects within the one-minute unit of coastline (Figure 2). Individual transect lines were located normal to baseline segments established parallel to the average historical shoreline positions. These baseline segments varied in length depending on the sinuosity of the shoreline, but were always divisible by 82 ft (25 m). Transects were automatically derived at 82 ft intervals along and perpendicular to the baseline segment by an electronic digitizer. Measurements of the intersection of each historical shoreline with each transect were then digitized and the differences in distance along the transect between intersections was used to calculate an average shoreline change rate. The difference for each time interval, divided by the number of years between surveys, produced an annual change rate. The mean rate of shoreline change (X) was calculated for each transect and each time interval as:

$$X = \frac{Y(ti) - (Y(ti-1))}{ti - (ti-1)} \qquad (1)$$

where Y is the distance from the baseline, ti is the survey date and varies from 2 to n (n equals the number of surveys). Overlapping transects were deleted to prevent duplicated rates for a particular site. As with all shoreline rate change calculations in this study, a negative (-) value

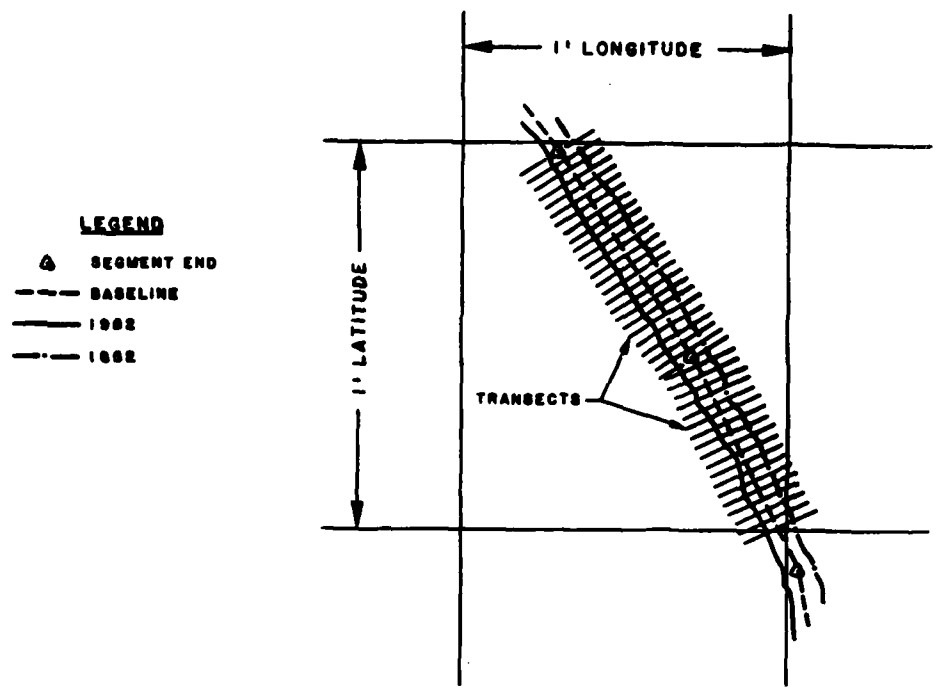

Figure 2. Definition sketch for shoreline change rate measurement

calculations in this study, a negative (-) value indicates landward movement and a positive value (+) seaward movement of the shoreline boundary.

34. A spatial average and standard deviation of the shoreline change rate was derived for each one-minute unit. This provided an average rate of shore-normal movement as well as a measurement of variability along the coast. The average shoreline change rate ($\bar{X}$) for each one-minute unit was calculated by averaging all the individual transect mean rates of change within the unit for the same overall time period. This spatially averaged rate $\bar{X}$ is

$$\bar{X} = \sum_{j=1}^{m} (X)_j \tag{2}$$

where m is the total number of transects for the one-minute unit. The spatial variation in shoreline change rate can be represented by the standard deviation (S) of the shoreline rate of change:

$$S = \sqrt{\frac{\sum_{j=1}^{m} ((X)_j - \bar{X})^2}{m-1}} \tag{3}$$

35. As with the shoreline change rates, areal changes are uniformly distributed over a time interval. Areas were measured by digitizing each survey time period within a one-minute unit. Each survey area A(ti) was specified using latitude and longitude and the shoreline (Figure 3). The latitude and longitude boundaries were invariant in time; only the shoreline boundary changed to create change in area. Closures for areas of river mouths, harbors, and other breaks in the shoreline were drawn on each map. Although arbitrary in nature, an alongshore continuation of the average adjacent shoreline orientation was used to derive each closure. The

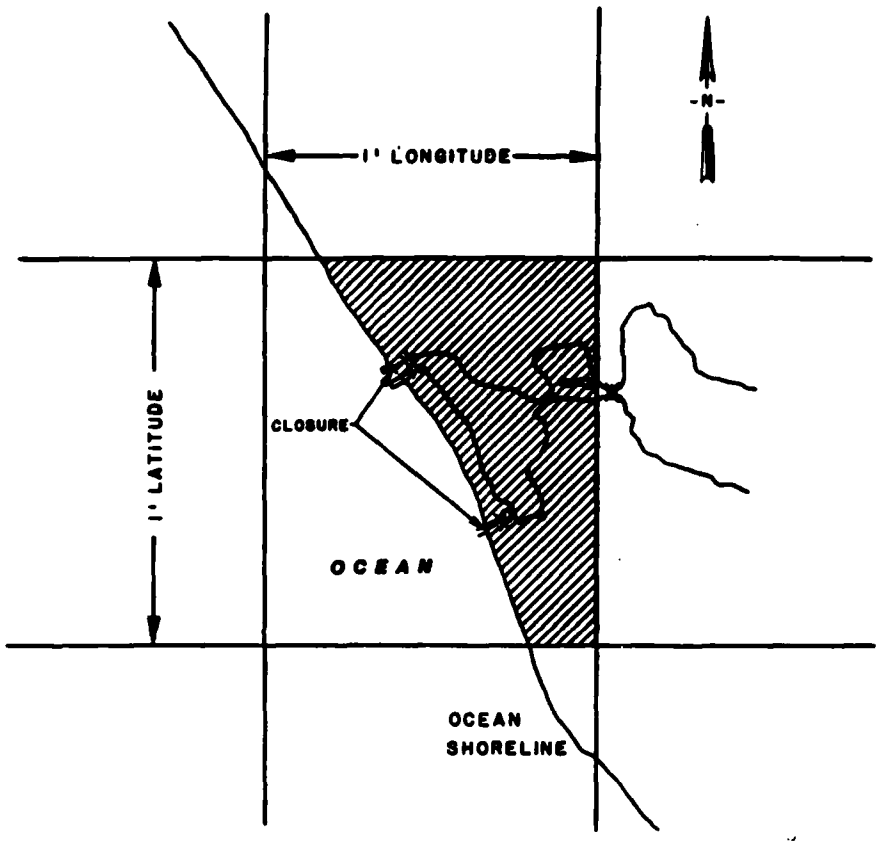

Figure 3. Definition sketch for area change measurement

difference in area for each time interval, divided by the number of years between surveys, produced an annual area change rate (Ci) for a particular survey:

$$Ci = \frac{A(ti) - (A(ti-1))}{ti - (ti-1)}$$

This areal change rate is the average net loss (-) or gain (+) of land area within each one-minute unit. The variability with time of shoreline changes can be represented by the standard deviation (S_z) of the areal change rates

$$S_z = \sqrt{\frac{\Sigma(Ci - c)^2}{n-1}} \tag{5}$$

where

$$c = \frac{1}{n} \sum_{i=1}^{n} Ci \tag{6}$$

36. In this report only the rates for the chosen time periods are shown. No change rates for the intermediate time periods occuring between the elected first and the last dates are listed Shoreline and areal rates of change and their variability were calculated for the maximum time record and for the period from 1933 to the most recent survey. The 1933 date was the earliest survey which provided a good measure of continuous coverage for the study area. Since there has been a dramatic increase in development along most of this coast, the shorter time period allows a look at the effects of man when compared to the longer time span. Tables 1 and 2 list shoreline rates of changes for both periods. Tables 3 and 4 are complementary land area change rates which coincide with the shoreline change rates and time periods.

Table 1

Yearly Shoreline Mean Rate of Change and Standard Deviation (ft)

Maximum Available Survey Record (≥ 1852 - 1982)

SURVEY TIME SPAN

Shoreline Longitude	1852-1982	1859-1982	1870-1982	1872-1982	1874-1982	1875-1982	1885-1982	1888-1982	1889-1982	1920-1982	1933-1982	1934-1982	1959-1982
118° 22'			.0 2.6										
21'			2.8 2.6										
20'			.4 .5										
19'			.4 .9										
18'			.6 .6										
San Pedro Breakwater		.9 .9											
10'				.5 1.9									
09'				1.4 2.4									
08'				3.4 1.4									
07'										-.8 4.5			
Anaheim Bay													3.5 4.8
Shoreline Latitude													
33° 43'													7.0 5.8
42'													5.9 1.8
41'													3.6 1.1
40'					.6 1.1								
39'					3.8 1.9								
38'						2.9 6.3							
37'						3.6 1.4							
36'						1.9 1.1							
35'						1.7 2.5							
34'												1.0 .8	
33'							.1 .8						
32'							.7 .7						
31'							-.2 .9						
30'												.4 1.7	
29'												-.2 1.6	
28'												.2 1.1	
Dana Harbor West												.4 .8	
San Juan Creek													
27'												7.9 4.3	
26'												4.9 1.7	
25'												1.5 1.1	
24'												1.3 7.8	
23'												-.1 1.3	
22'									-.3 1.5				
21'									1.6 1.4				
20'									1.8 .7				
19'									.9 .8				
18'									.6 .7				
17'									.4 .8				
16'									-.6 1.0				
15'									.0 .5				
14'								.4 .5					
13'								2.8 .5					
12'								4.3 3.0					
11'								1.5 10.9					
10'								2.0 .9					
09'								1.2 .6					
08'								.3 .6					
07'								1.8 1.0					
06'								.9 1.5					
05'								.5 .4					
04'								.5 .7					
03'								.0 .7					
02'								1.9 .7					
01'								2.2 .6					
33° 00'								2.1 .6					
59'									1.9 .7				
58'									.3 .6				
57'									.6 .8				
56'									.5 .4				
55'									.2 .5				
54'									.0 .8				
53'									.1 .4				
52'									.4 .5				
51'									-.3 .5				
50'									-.5 .5				
49'									.7 .7				
48'									.6 .7				
47'	-.1 .6												
46'	-.4 .3												
45'	-.4 .3												
44'											-1.7 6.1		
43'											-.4 1.2		
42'											.4 .7		
41'											.2 .4		
Point Loma											.2 .4		
San Diego Bay 41'									.2 .8				
San Diego Bay													
41'	-.4 .3												
40'	.1 .3												
39'	8.0 2.6												
38'	3.7 .8												
37'	3.3 .6												
36'	2.4 .6												
35'	2.4 .4												
34'	1.5 .5												
33'	1.4 .4												
U.S./Mexico Border	1.5 .8												

The mean rate of change is underlined and listed to the left of the standard deviation value

Table 1

Yearly Shoreline Mean Rate of Change and Standard Deviation (ft)

Maximum Available Survey Record (≥ 1852 - 1982)

SURVEY TIME SPAN

1859-1982	1870-1982	1872-1982	1874-1982	1875-1982	1885-1982	1888-1982	1889-1982	1920-1982	1933-1982	1934-1982	1959-1982	Shoreline Longitude
	.0 2.6											118° 22'
	2.6 2.6											21'
	.4 .5											20'
	.4 .9											19'
	.4 .6											18'
.9 .9		.5 1.9										San Pedro Breakwater
		1.6 2.4										10'
		1.6 1.4										09'
								-.8 4.5				08'
											3.5 4.8	07'
												Anaheim Bay
												Shoreline Latitude
											7.0 5.8	33° 43'
											5.9 1.8	42'
											3.6 1.1	41'
			.6 1.1									40'
			1.8 1.9									39'
				2.9 6.3								38'
				1.6 1.4								37'
				1.9 1.1								36'
				1.7 2.5								35'
										1.0 .8		34'
					.1 .8							33'
					.1 .7							32'
					.1 .9							31'
										.4 1.7		30'
										.2 1.6		29'
										.2 1.1		28'
										.4 .8		Dana Harbor West
												San Juan Creek
										7.9 4.3		27'
										3.3 1.7		26'
										1.3 1.1		25'
										1.3 7.8		24'
										1.1 1.3		23'
							.3 1.5					22'
							.1 1.4					21'
							.1 .8					20'
							.2 .8					19'
							.2 .7					18'
							.2 .8					17'
							.1 1.0					16'
							.1 .5					15'
						.4 .5						14'
						.4 .5						13'
						.4 3.0						12'
						.4 10.9						11'
						.4 .9						10'
						.4 .6						09'
						.4 .6						08'
						.4 1.0						07'
						.4 1.5						06'
						.4 .6						05'
						.4 .7						04'
						.4 .7						03'
						.4 .6						02'
						.4 .6						01'
							1.9 .7					33° 00'
							.1 .6					59'
							.6 .8					58'
							.5 .4					57'
							.2 .5					56'
							.6 .8					55'
							.1 .4					54'
							.4 .5					53'
							.5 .5					52'
							.5 .5					51'
							.7 .7					50'
							.6 .7					49'
												48'
												47'
												46'
												45'
												44'
									-1.7 6.1			43'
									-.4 1.2			42'
									.4 .7			41'
									.6 .4			Point Loma
									.2 .4			San Diego Bay 41'
							.2 .8					San Diego Bay
												41'
												40'
												39'
												38'
												37'
												36'
												5'
												34'
												33'
												U.S./Mexico Border

The mean rate of change is underlined and listed to the left of the standard deviation value

Table 2

Yearly Shoreline Mean Rate of Change and Standard Deviation (ft)

Maximum Available Survey Record ($\geq$1933 - 1982)

Shoreline Longitude	SURVEY TIME SPAN 1933-1982		1934-1982		1959-1982	
118° 22'					.0	2.6
21'					2.8	2.6
20'					.4	.5
19'					.4	.9
18'					.6	.6
San Pedro Breakwater					.1	.6
10'					.7	2.5
09'					2.6	3.2
08'					3.3	2.1
07'					-.1	5.1
Anaheim Bay					3.5	4.8
Shoreline Latitude						
33° 43'					7.0	5.8
42'					5.9	1.8
41'					3.6	1.1
40'					.6	1.1
39'					3.8	1.9
38'					2.9	6.3
37'					4.3	1.5
36'					2.0	1.5
35'					1.5	2.1
34'			.9	.9		
33'			1.1	.8		
32'			.7	.7		
31'			1.3	.9		
30'			1.4	1.7		
29'			1.3	1.6		
28'			1.1	1.1		
Dana Harbor West			.4	.8		
San Juan Creek						
27'			2.9	4.3		
26'			2.9	1.7		
25'			1.5	1.1		
24'			1.3	7.8		
23'			1.1	1.3		
22'			1.3	1.5		
21'			1.6	1.4		
20'			1.8	.7		
19'			.9	.8		
18'			.6	.7		
17'			.4	.8		
16'			1.6	1.0		
15'			.0	.5		
14'			.4	.5		
13'			2.8	.5		
12'			3.3	3.0		
11'			5.5	10.9		
10'			2.0	.9		
09'			1.3	.6		
08'			.3	.6		
07'			1.8	1.0		
06'			.9	1.5		
05'			.5	.4		
04'			.3	.7		
03'			.0	.7		
02'			1.9	.7		
01'			2.2	.6		
33° 00'			2.1	.6		
59'			1.9	.7		
58'			.3	.6		
57'			.6	.8		
56'			.5	.4		
55'			.2	.5		
54'			.0	.8		
53'			.1	.4		
52'		.4		.5		
51'		.2		.6		
50'		.5		.7		
49'		.8		.9		
48'		.8		.9		
47'		.7		.8		
46'		.3		.4		
45'		.3		.4		
44'		.3		5.9		
43'		.5		1.2		
42'		.5		.7		
41'		.2		.4		
Point Loma		.2		.4		
San Diego Bay 41'		.1		.8		
San Diego Bay						
41'		.3		.5		
40'		.4		.6		
39'		.0		3.4		
38'		.1		1.5		
37'		.1		1.6		
36'		.0		.9		
35'		.0		.8		
34'		.0		.5		
33'		.0		.6		
U.S./Mexico Border		.7		1.0		

The mean rate of change is underlined and listed to the left of the standard deviation value

Table 3

Yearly Land Area Mean Rate of Change and Standard Deviation (ft^2)

Maximum Available Survey Record (≥1852 - 1982)

Shoreline Longitude	SURVEY TIME SPAN 1852-1982	1859-1982	1870-1982	1872-1982	1874-1982	1873-1982	1885-1982	1888-1982	1889-1982
118° 22'			3280.7 3506.0						
21'			18801.5 9707.4						
20'			5626.6 10396.8						
19'			6794.9 13561.0						
18'			15493.2 38964.8						
San Pedro Breakwater		11179.3 6930.1							
10'				8611.7 22984.1					
09'				9899.2 22757.1					
08'				18334.0 30805.8					
07'									-845
Anaheim Bay									
Shoreline Latitude									
33° 43'									
42'									
41'									
40'					-2502.3 45797.2				
39'						30139.7 42170.3			
38'						20495.9 5817.7			
37'						50641.2 33941.0			
36'						33758.6 65562.0			
35'						18473.1 39333.5			
34'									
33'							15709.7 48667.5		
32'							11497.8 37279.4		
31'							599.7 19175.0		
30'									
29'									
28'									
Dana Harbor West									
San Juan Creek									
27'									
26'									
25'									
24'									
23'									
22'									
21'									
20'									
19'									
18'								81.6 24427.6	
17'								-2700.6 17665.1	
16'								1150.3 11413.9	
15'								821.5 17880.4	
14'								27614.8 30332.0	
13'								46710.9 34047.5	
12'								40502.1 24222.0	
11'								13647.8 23910.3	
10'								15998.1 33880.4	
09'								16198.9 29552.4	
08'								13030.9 35272.2	
07'								7570.0 15694.9	
06'								3154.2 10903.1	
05'								3247.2 19766.5	
04'								6960.1 2986.9	
03'								15133.0 13893.5	
02'								15071.9 16154.6	
01'								12298.8 14481.1	
33° 00'								12406.0 18096.2	
59'									3432.2 6318.1
58'									5560.3 8150.0
57'									3016.1 5062.7
56'									2621.5 5733.4
55'									1309.5 6242.6
54'									4190.9 9379.3
53'									6922.7 31728.1
52'									-1150.4 15312.6
51'									-4097.2 11883.6
50'									6309.5 5867.2
49'									4635.3 11438.4
48'									-4451.3 5213.4
47'	-3213.5 6515.7								
46'	-2639.6 15412.7								
45'	102716.8 156895.6								
44'									
43'									
42'									
41'									
Point Loma									
San Diego Bay 41'									
San Diego Bay									
41'	88536.5 69478.6								
40'	39362.8 56937.2								
39'	28307.8 68991.2								
38'	20276.8 45281.5								
37'	-191215.3 384746.2								
36'	8751.0 15025.7								
35'	9280.5 13449.1								
34'	10204.8 24761 3								
33'	-14849.0 20262..0								
U.S./Mexico Border	-7469.2 23449.9								

The mean rate of change is underlined and listed to the left of the standard deviation value

Table 3

Yearly Land Area Mean Rate of Change and Standard Deviation (ft^2)

Maximum Available Survey Record (≥1852 - 1982)

SURVEY TIME SPAN										
1982	1875-1982	1883-1982	1888-1982	1889-1982	1920-1982	1933-1982	1934-1982	1959-1982		Shoreline Longitude
										118 22'
										21'
										20'
										19'
										18'
										San Pedro Breakwater
										10'
										09'
										08'
										07'
					-8451.0 57015.3			26500.7	18863.9	Anaheim Bay
										Shoreline Latitude
								66773.1	38368.1	33 43'
								45205.5	18067.5	42'
								26593.3	23721.8	41'
45797.2										40'
	30130.7	42170.3								39'
	30495.9	5817.7								38'
	30641.2	33941.0								37'
	33758.6	65562.0								36'
	18473.1	39333.5								35'
							14205.6 37022.7			34'
										33'
		15799.7 48647.5								32'
		11497.8 37279.4								31'
		599.7 19175.0								30'
							7763.7 30013.2			29'
							-2385.2 13325.2			28'
							2382.2 7282.0			Dana Harbor West
							5248.5 7276.8			San Juan Creek
							15057.0 80840.7			27'
							54115.4 34261.9			26'
							7124.4 8791.7			25'
							-2095.8 18345.2			24'
							-1987.7 18547.7			23'
							23774.2 31787.0			22'
							20304.0 21150.6			21'
							8582.2 4876.4			20'
							7162.5 19894.9			19'
			81.6 24427.6							18'
			-3700.6 17665.1							17'
			1150.3 11413.9							16'
			821.5 17880.4							15'
			27614.8 30332.0							14'
			46710.9 34047.5							13'
			40502.1 24222.0							12'
			32647.8 23920.3							11'
			15998.1 33880.4							10'
			16198.9 29552.4							09'
			15030.9 35272.2							08'
			7570.0 15694.9							07'
			3154.2 10903.1							06'
			3247.2 19766.5							05'
			6960.1 2986.9							04'
			15133.0 13893.5							03'
			15071.9 16154.6							02'
			12298.8 14481.1							01'
			12406.0 18096.2							33 00'
				3432.2 6318.1						59'
				5560.3 8150.0						58'
				3016.1 5062.7						57'
				2621.5 5733.4						56'
				1309.5 6242.6						55'
				4190.9 9379.3						54'
				6922.7 31728.1						53'
				-1150.4 15312.6						52'
				-4097.2 11883.6						51'
				6309.5 5867.2						50'
				4933.3 11438.4						49'
				-4451.3 5213.4						48'
										47'
										46'
										45'
										44'
										43'
										42'
										41'
						-671.2 4107.7				Point Loma
						1069.6 5898.0				San Diego Bay 41'
						1502.8 2717.8				San Diego Bay
						3196.5 5281.8				41'
						3993.1 3097.0				40'
										39'
										38'
										37'
										36'
										35'
										34'
										33'
										U.S./Mexico Border

The mean rate of change is underlined and listed to the left of the standard deviation value

2

Table 4

Yearly Land Area Mean Rate of Change and Standard Deviation (ft^2)

Maximum Available Survey Record ($\geq$ 1933 - 1982)

Shoreline Longitude	SURVEY TIME SPAN 1933-1982		1934-1982		1959-1982	
118° 22'					3792.4	4438.6
21'					24142.7	8488.2
20'					6184.7	13387.3
19'					7406.3	17475.2
18'					21270.2	49297.8
San Pedro Breakwater					6287.8	7749.0
10'					-8302.5	9369.0
09'					-2623.9	2774.3
08'					6543.0	1310.6
07'					-30412.2	11648.9
Anaheim Bay					26500.7	18863.9
Shoreline Latitude						
33° 43'					66773.1	38368.1
42'					45205.5	18067.5
41'					26593.3	23721.8
40'					222.9	58935.2
39'					26038.2	53471.5
38'					32554.8	6785.5
37'					63044.9	38189.3
36'					-13529.6	52841.4
35'					-7390.7	23910.8
34'			14205.6	37022.7		
33'			17232.1	56449.4		
32'			14604.4	42911.8		
31'			-838.7	22111.6		
30'			7765.7	30013.2		
29'			-2385.2	13375.2		
28'			2382.2	7282.0		
Dana Harbor West			5248.5	7276.8		
San Juan Creek						
27'			35057.0	80840.7		
26'			34715.4	34261.9		
25'			7124.4	8791.7		
24'			-2095.8	18345.2		
23'			-1987.7	18547.7		
22'			23774.2	31787.0		
21'			20304.0	21150.6		
20'			8582.2	4876.4		
19'			7182.5	19894.9		
18'			-1019.4	28305.3		
17'			-3470.6	20520.4		
16'			1896.2	13186.1		
15'			-527.3	20600.0		
14'			28288.9	35219.4		
13'			50747.9	38811.0		
12'			43908.1	27391.4		
11'			9249.7	27034.7		
10'			19445.4	38818.3		
09'			21693.4	32715.9		
08'			18986.7	40289.5		
07'			10443.2	17402.0		
06'			3042.1	12666.5		
05'			2984.6	22960.3		
04'			8596.5	1550.3		
03'			18737.7	14604.5		
02'			18865.1	17335.3		
01'			16388.2	14929.6		
33° 00'			14753.6	20548.7		
59'			2209.8	6965.0		
58'			2274.9	7128.3		
57'			1869.4	5465.1		
56'			-27.5	4372.2		
55'			81.9	6869.0		
54'			2037.7	10675.9		
53'			11546.5	35805.6		
52'	-1383.5	17773.6				
51'	-4270.7	13768.2				
50'	2098.1	6650.8				
49'	6816.8	12629.2				
48'	-3695.4	5578.6				
47'	-2902.8	7871.6				
46'	-3223.8	19632.7				
45'	12092.7	60548.4				
44'	-871.2	4107.7				
43'	3069.8	5098.0				
42'	1502.8	2717.8				
41'	3136.5	5281.8				
Point Loma	3993.1	3097.0				
San Diego Bay 41'	1284.7	5643.9				
San Diego Bay						
41'	118978.9	76727.5				
40'	59365.6	67816.4				
39'	51638.0	82275.7				
38'	34698.2	53286.2				
37'	24615.6	25291.6				
36'	14820.1	17216.8				
35'	17285.9	11650.5				
34'	11545.0	28657.4				
33'	-20318.1	235195.0				
U.S./Mexico Border	-11612.8	26198.8				

The mean rate of change is underlined and listed to the left of the standard deviation value

PART V: RESULTS AND PREDICTION OF FUTURE SHORELINE AND AREA CHANGES

Limitations on Prediction

37. Historical shoreline change data may provide useful information with which to predict future changes. However, when the causes of change are not well known, it is difficult to make such predictions using only past trends. Particular problems occur with respect to interpretation of shoreline movement for this study reach, because the movement is generally episodic and sometimes catastrophic. The lack of a lengthy historical record for some areas affects the prediction of future trends. Analysis of shoreline movement trends for short time intervals are much more subject to cyclic variations in the natural systems such as weather patterns, as suggested by Kuhn and Shepard (1984). Apparent trends derived from shorter time frames may often differ greatly from those for longer time interval. Man's development of upland and coastal zones has influenced shoreline movement in recent years. As further development occurs, problems with accelerated movement may develop. Therefore, the results of this study should be used cautiously in forecasting changes in shoreline behavior. This section treats shoreline and area change prediction separately and presents the differences between the available long and short term periods.

Spatial Shoreline Change Predictions

38. Many changes in shoreline position are likely related to local conditions. Because the factors influencing shoreline movement within the study reach were not addressed, an accurate assessment of prediction is hazardous. However, the alongshore variations exhibited in both mean shoreline change rates and standard deviations indicate the uniformity, or lack thereof, which exists spatially along the coast. The standard deviation is the variance from the mean rate of change per year. A high standard

deviation indicates that at some of the 25 m intervals along the coast, significantly higher or lower mean rates of change exist. A low standard deviation indiates that the shoreline is moving uniformly, or relatively so, for the entire one-minute coastal unit.

Temporal Prediction

39. Because the shoreline change rate is a spatially averaged rate of movement, a measure of variability over time was needed to properly assess past trends. The area mean rate of change indicates the change in land area per year. However, the standard deviation differs from the shoreline change rate standard deviation. Since the base of measurement is the whole land mass area for each one-minute unit for each date, the variance in mean rate of change relates to time only. Thus, if a high standard deviation occurs for an areal measurement, it means that the unit has experienced non-uniform change in land mass for the survey time span. A low standard deviation would indicate a uniform or more consistent rate of change in land area over the survey time span.

40. Both the time and spatial variations are equally important. However, due to the sometimes short, intermittent, and non-uniform frequency of survey information in some areas, higher standard deviations may exist than for adjacent areas with longer and more complete historical data. This can produce misleading information and caution should be exercised when making trend predictions of boundary positions.

RESULTS

41. Of the 87 cases for which areal and shoreline rate of change values were calculated, twenty (23%) had a time span of 62 years or less. Nineteen of these had survey data for a 49 year or less time span. The areas with a short available survey record are located primarily in the northern study

reach from the Alamitos Bay area to 1 mile north of Huntington Beach, a 1 mile stretch at Crystal Cove, and the area from South Laguna to San Clemente. Another section exists in the southern study reach from Ocean Beach to Point Loma. The only reach spanning the maximum 130 year study time period (1852-1982) is the one from North Island to the U.S./Mexico border. This last area represents 11 percent of the total study. The remaining areas fall primarily within a 90-100 year time span range.

42. The shoreline rate of change has been graphed for the periods 1852-1982 (Figure 4) and 1933-1982 (Figure 5). Graphs of the respective available time spans and the number of available surveys are also presented (Figures 6 & 7) and apply to the areal measurements as well. Both time periods exhibit accretionary trends for 73 (84%) of the 87 one-minute units. The patterns of movement for both periods are much alike, with the differences being mainly higher rates for the shorter time span. Movement is sporadic in the northern reach and stabilizes in the southern portion with only a few exceptions.

43. Areal change rates were graphed for both time periods 1852-1982 (Figure 8) and 1933-1982 (Figure 9). Mostly they display an increase in land area for both periods. However, the shorter time span shows an increase in land area for only 66 (76%) of the 87 units. The longer time span exhibited an increase in 72 (83%) of the units. The southern portion of the study reach (San Diego Bay to the U.S. Mexican Border) experienced the most dynamic areal change over time. This is indicated by the high standard deviation for the area mean rate of change which occurs in the Mission Beach and Silver Strand areas.

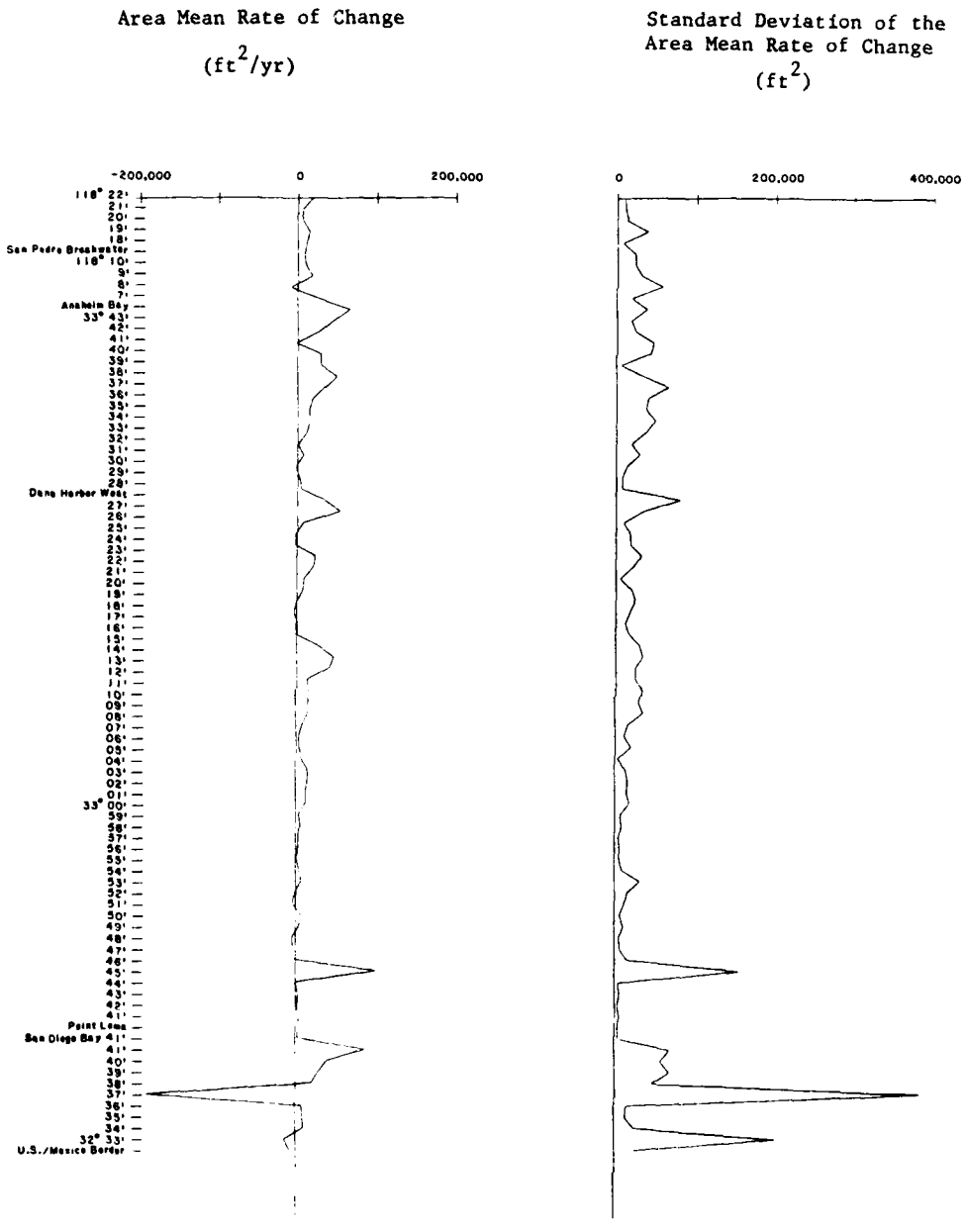

Figure 4. Area mean rate of change and standard deviation, maximum available survey record (≥1852 - 1982)

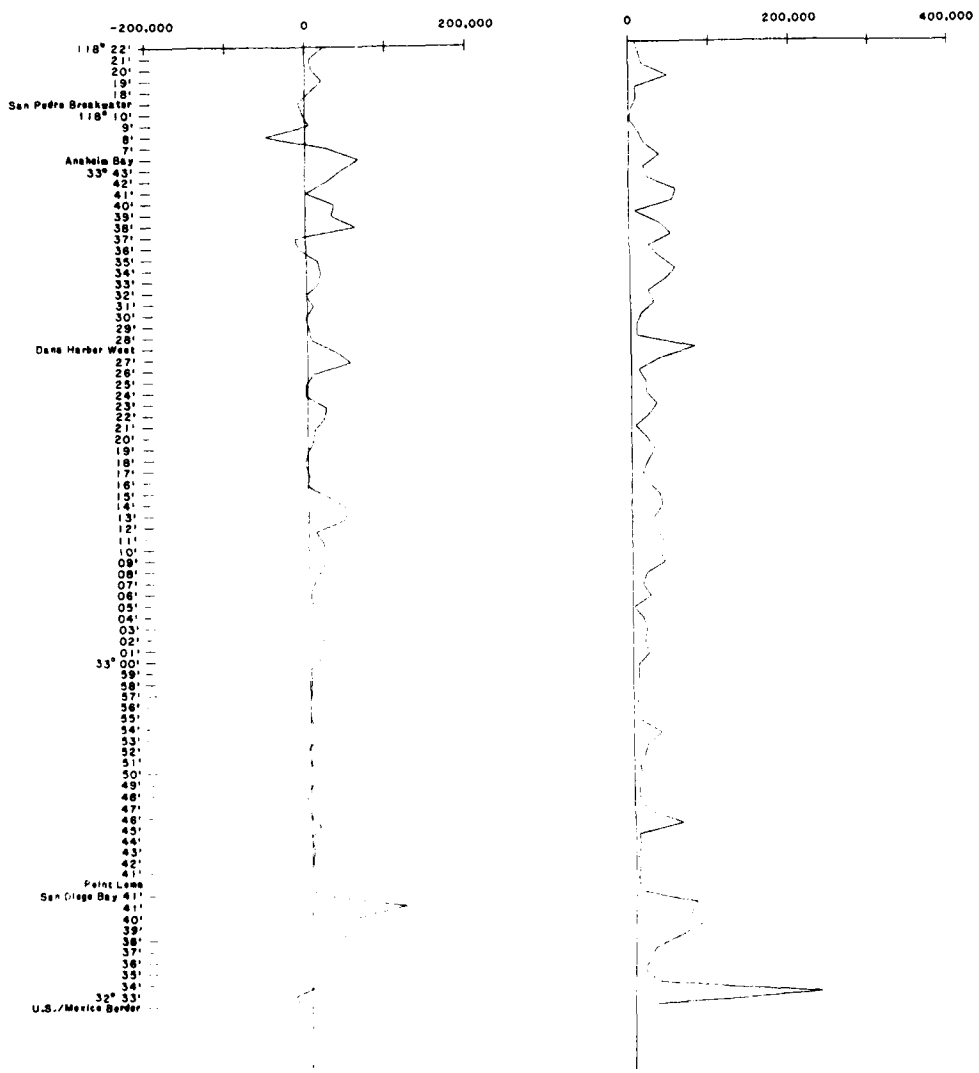

Figure 5. Area mean rate of change and standard deviation, maximum available survey record (≥1933 - 1982)

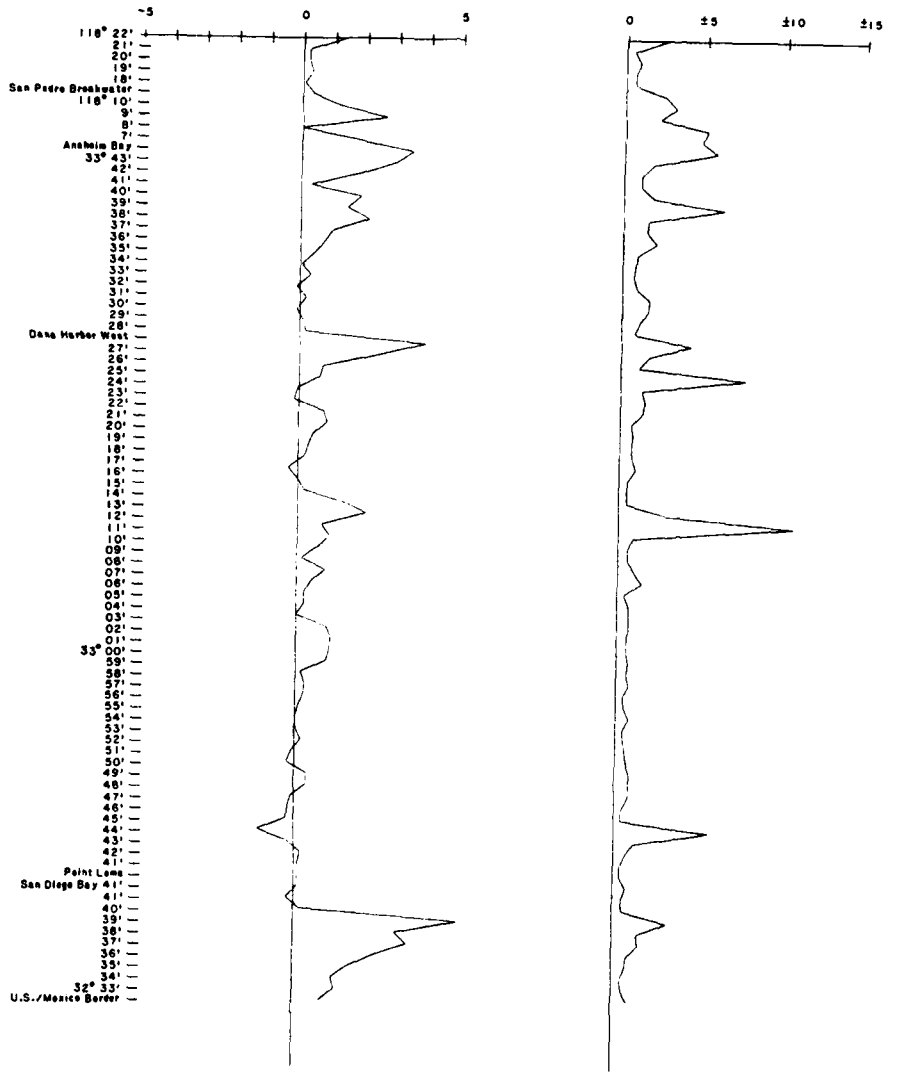

Figure 6. Shoreline mean rate of change and standard deviation, maximum available survey record (≥1852 - 1982)

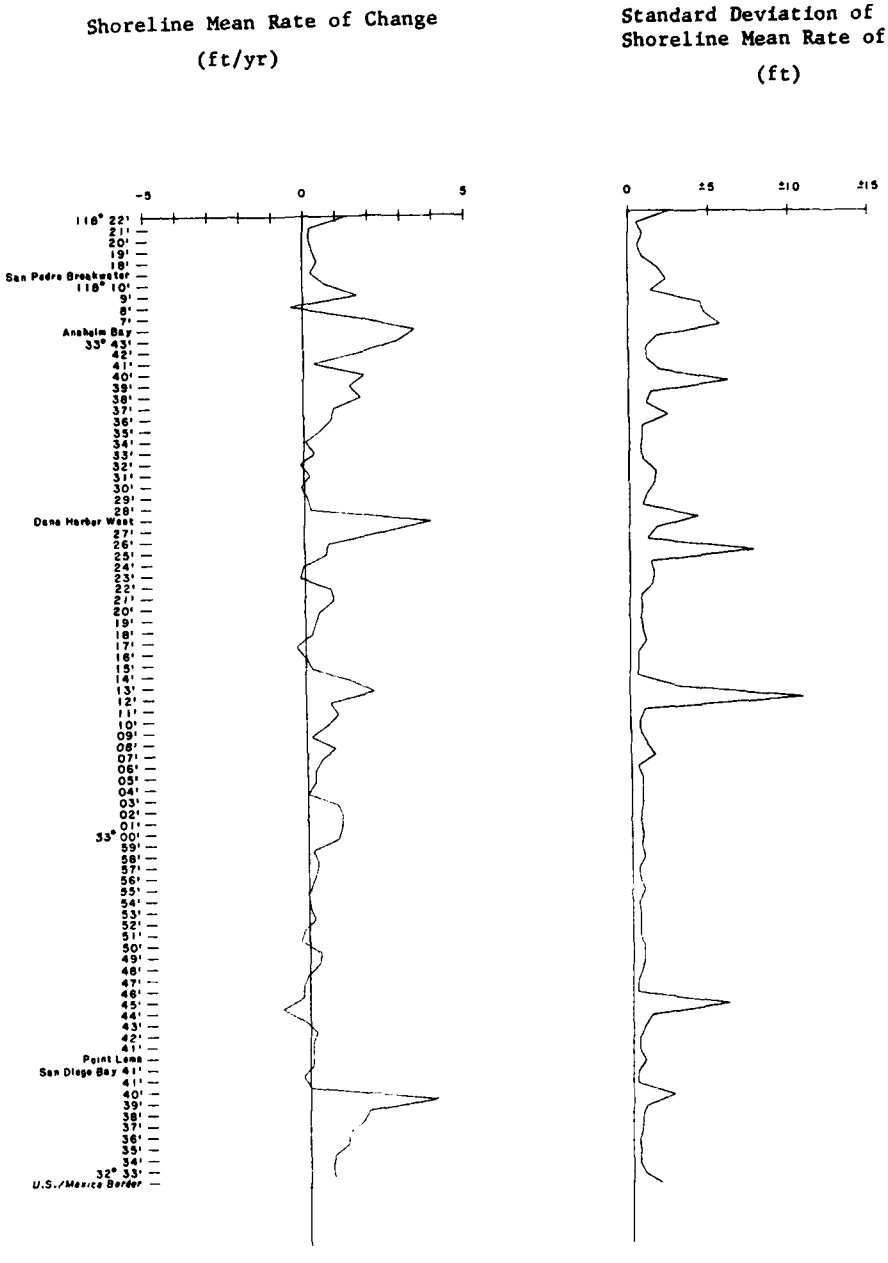

Figure 7. Shoreline mean rate of change and standard deviation, maximum available survey record (≥1933 - 1982)

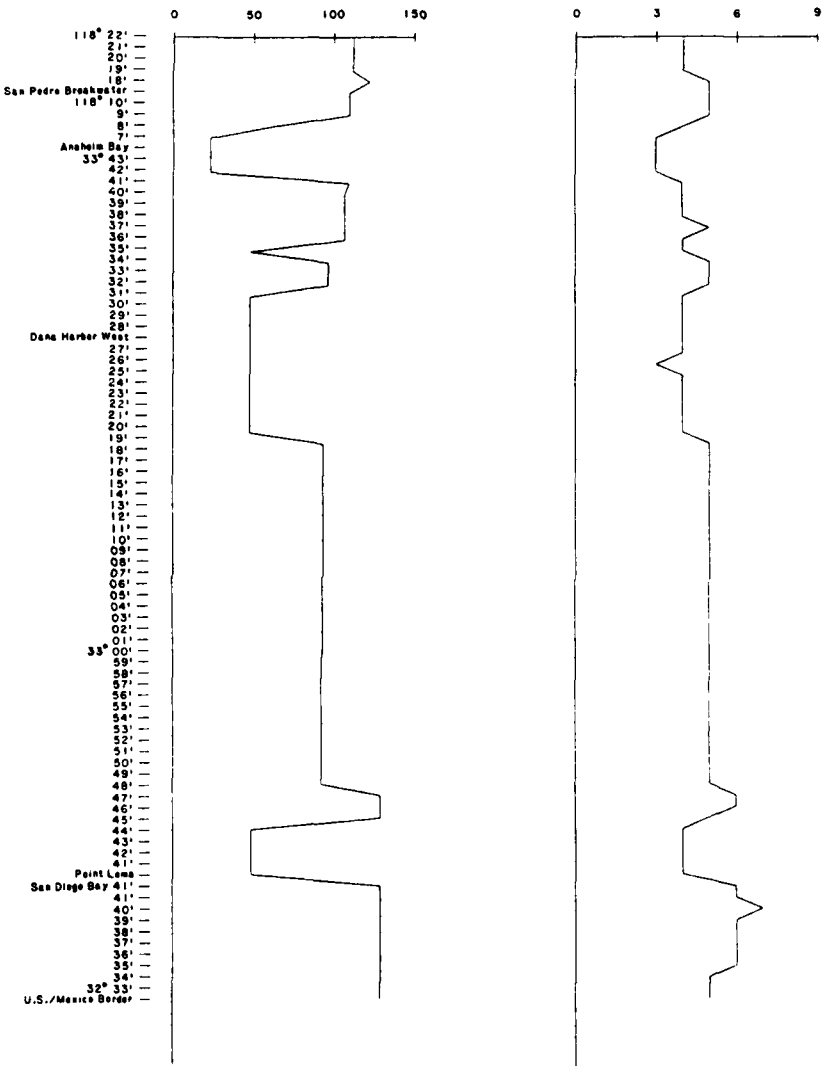

Figure 8. Survey time span and number of surveys, maximum available survey record (≥1852 - 1982)

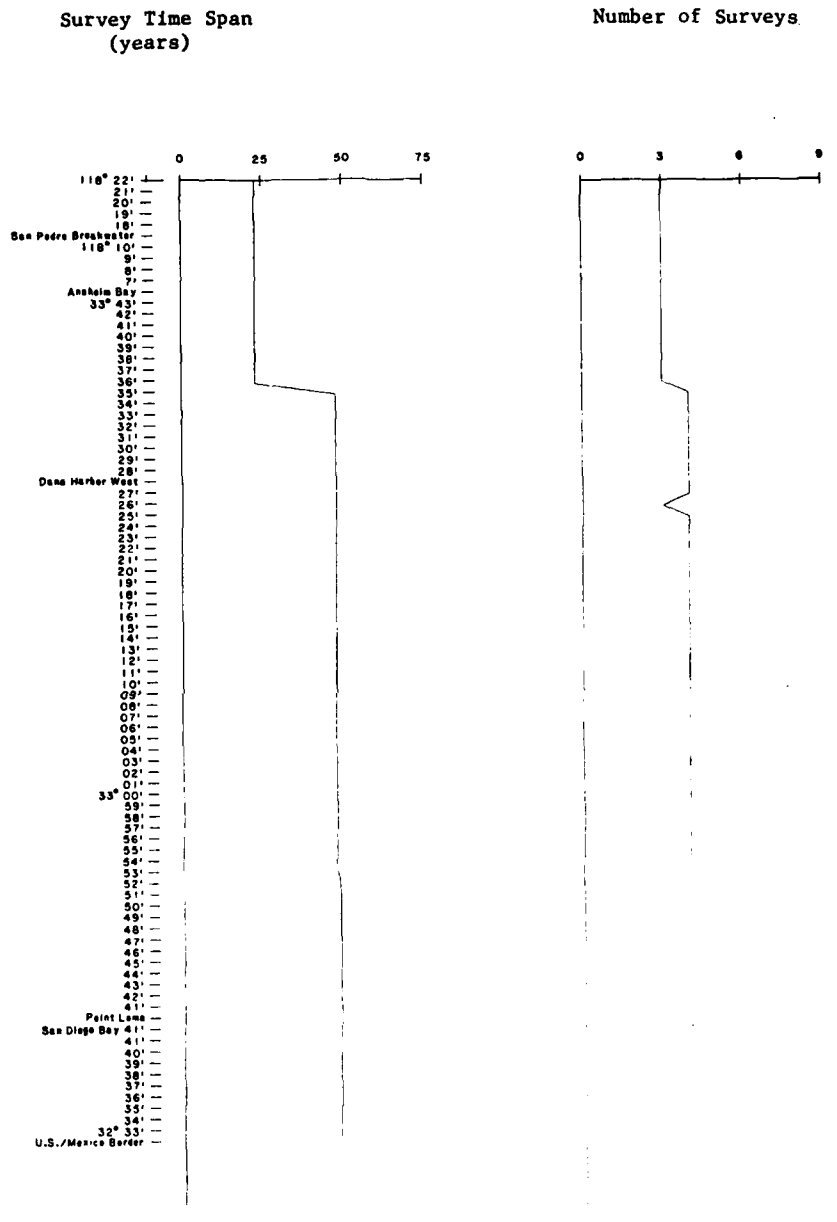

Figure 9. Survey time span and number of surveys, maximum available survey record (≥1933 - 1982)

PART VI: SUMMARY AND CONCLUSIONS

44. Shoreline movement maps of the Pacific Ocean and bay shoreline from Point Portuguese south to the U.S./Mexico Border were produced using historic NOS shoreline maps. Figures 10-24 show the area of coverage for each map. The overall accuracy of the shoreline movement maps is estimated to be at least within $\pm$ 39.5 ft. Using digitizing procedures, average shoreline and areal change rates were quantified for one-minute latitude/longitude units of the study coast. Predicting the future magnitude of shoreline and land area change rates is difficult because of unquantifiable changes in the processes which drive shoreline change. Efforts to analyze some areas were hindered by lack of a lengthy and consistent historical record. Analysis is further complicated by the lack of adequate cause and effect relationships that would provide significant information necessary for predicting or explaining the shoreline movement. For example, bluff erosion, a critical problem for this study reach, has greatly influenced the shoreline movement in recent years. Additionally, man's development of the coastal zone area has probably played a key role in altering the rates of shoreline change in certain areas.

45. Comparison of the change rates and their standard deviations for both the shoreline movement and land area measurements indicates the conditions (stability to high variability) that exist over time and along the coast. While shorter time spans tend to mimic the longer trends for the majority of the study reach, no confident predictions of future shoreline position can be made. Careful analysis of the spatial and temporal variations must be considered. Some areas of the study reach exhibit variable behavior both along the coast as well as over time. This complex behavior points to the need for additional information in order to make an informed predition of shoreline position.

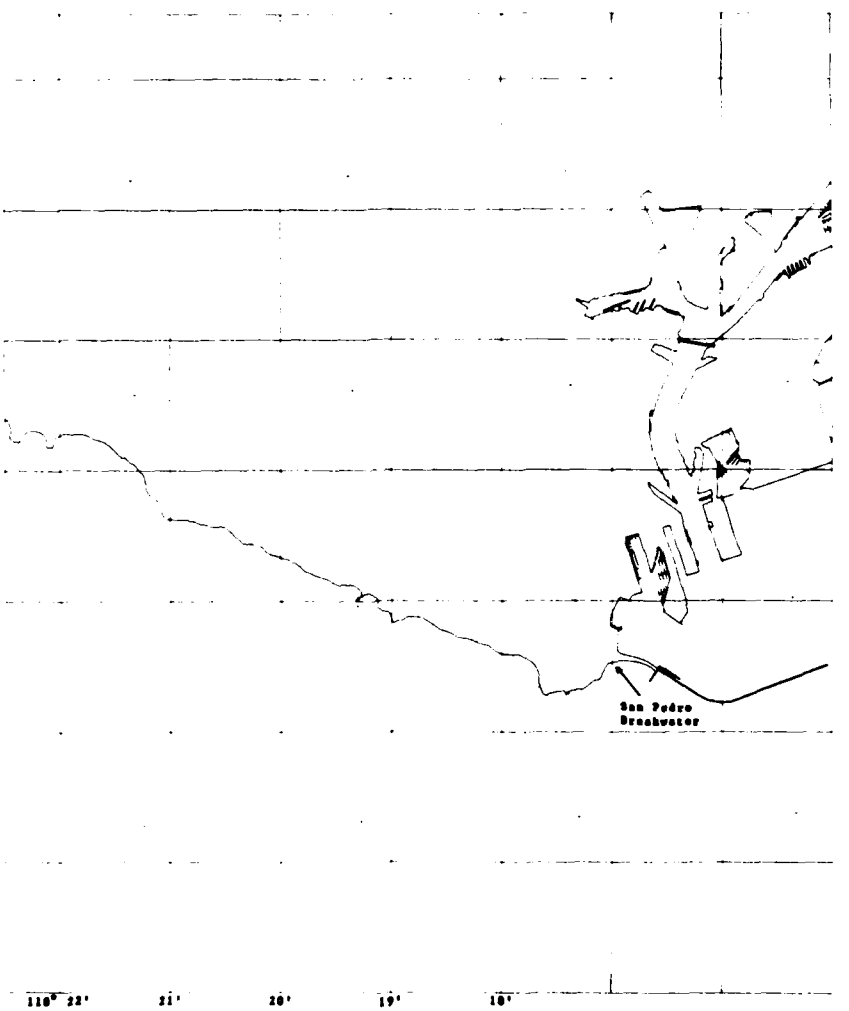

Figure 10. Map No. 15 - Torrance/San Pedro

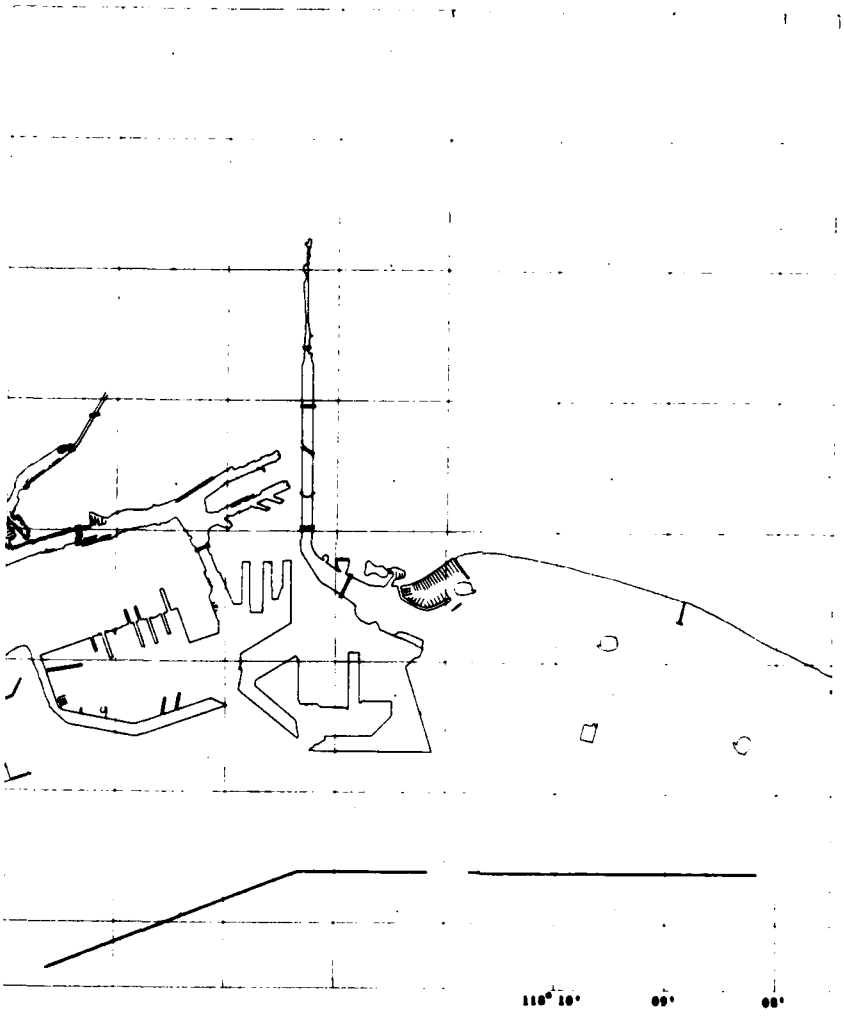

Figure 11. Map No. 14 - Long Beach

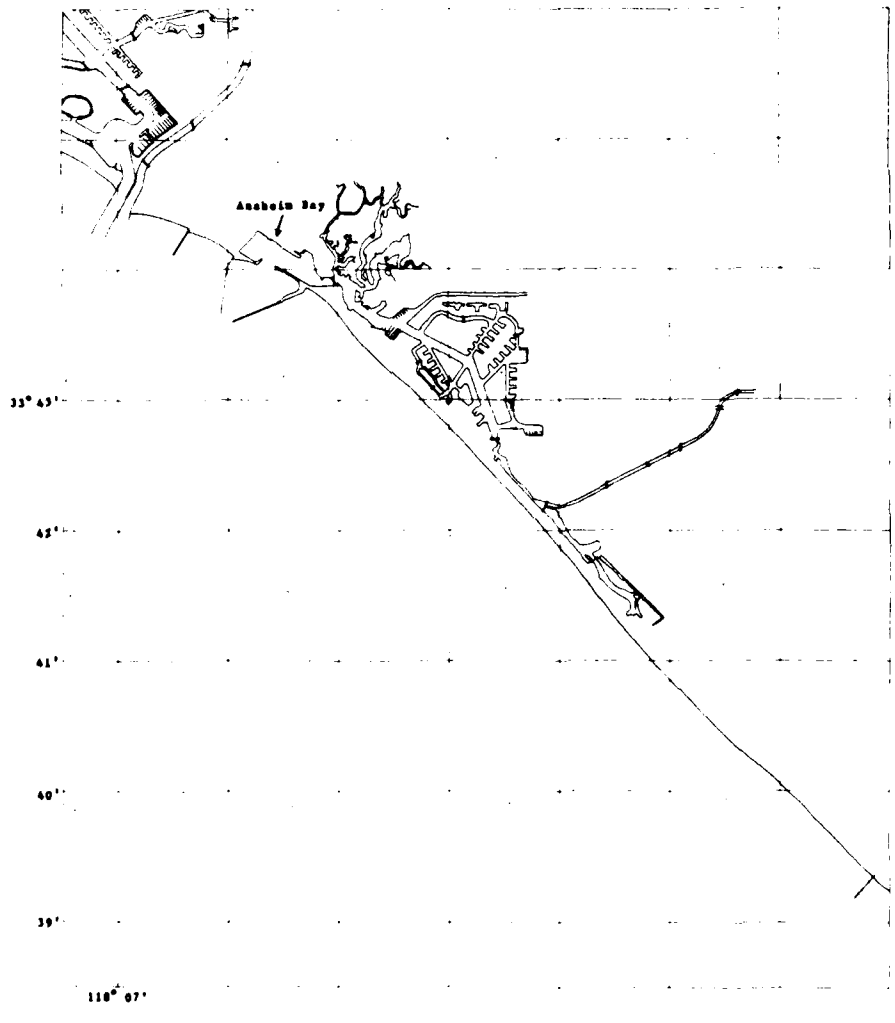

Figure 12. Map No. 13 - Seal Beach/Los Alamitos

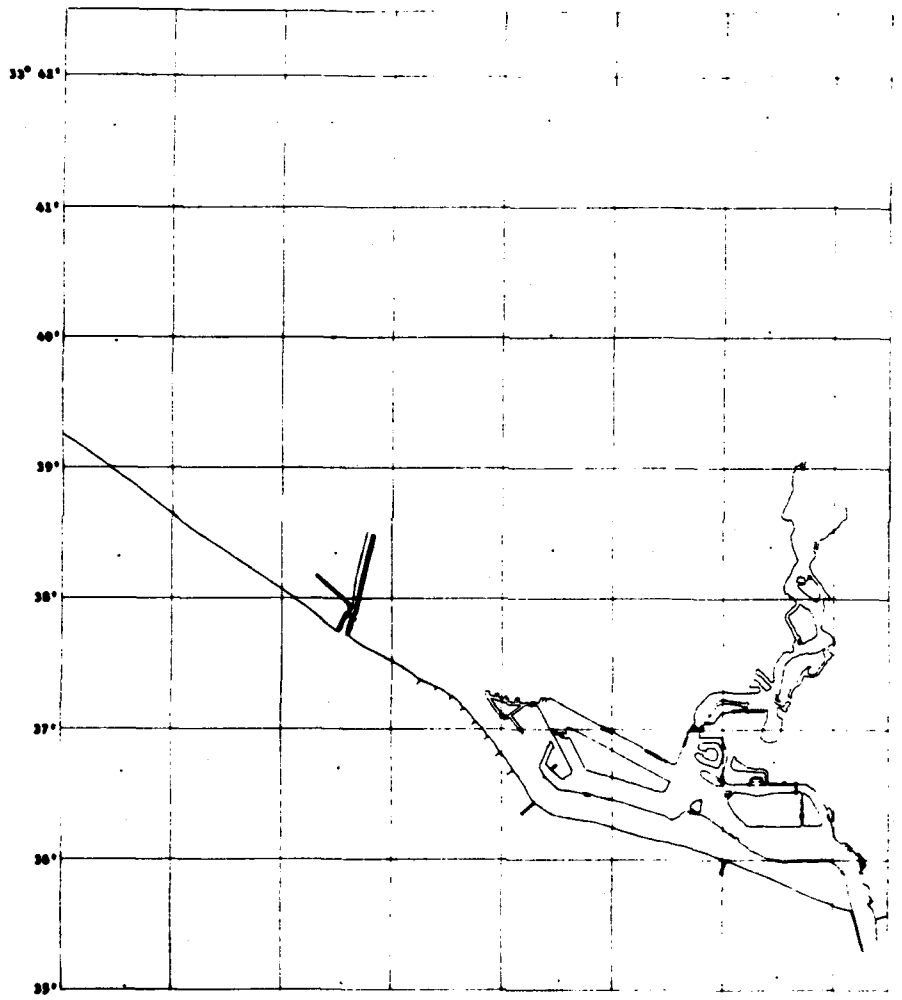

Figure 13. Map No. 12 - Newport Beach

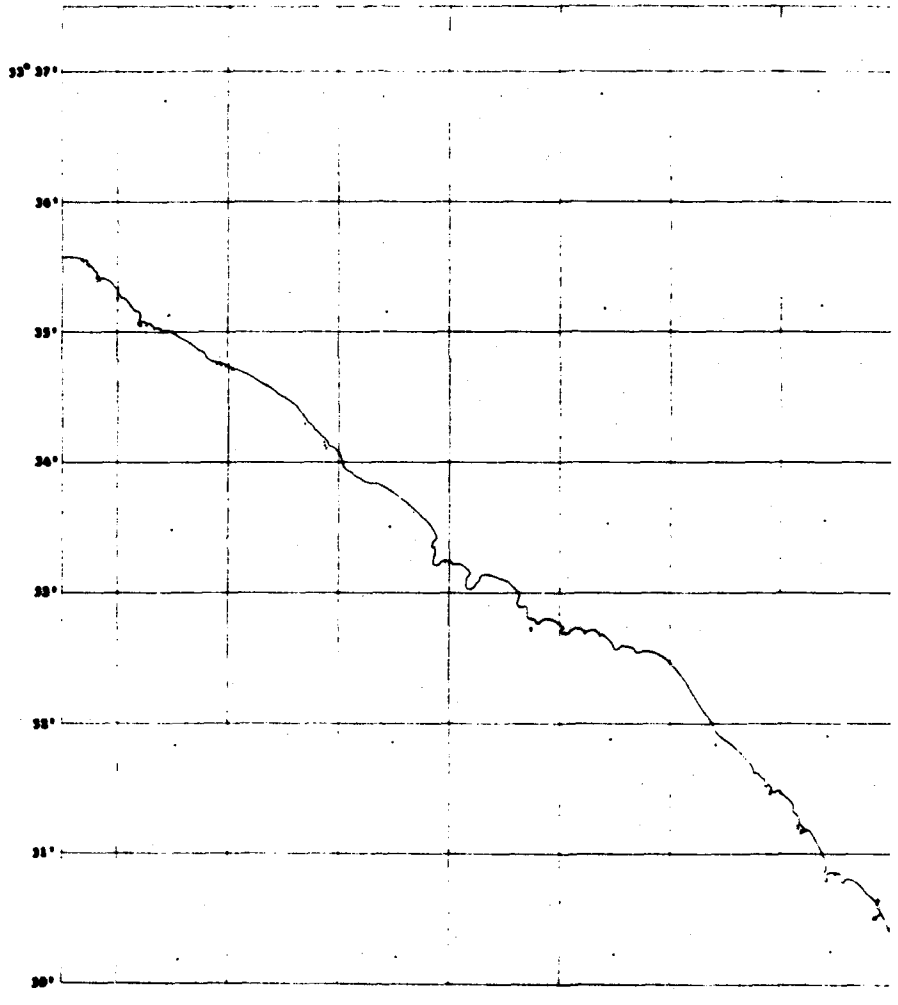

Figure 14. Map No. 11 - Laguna Beach

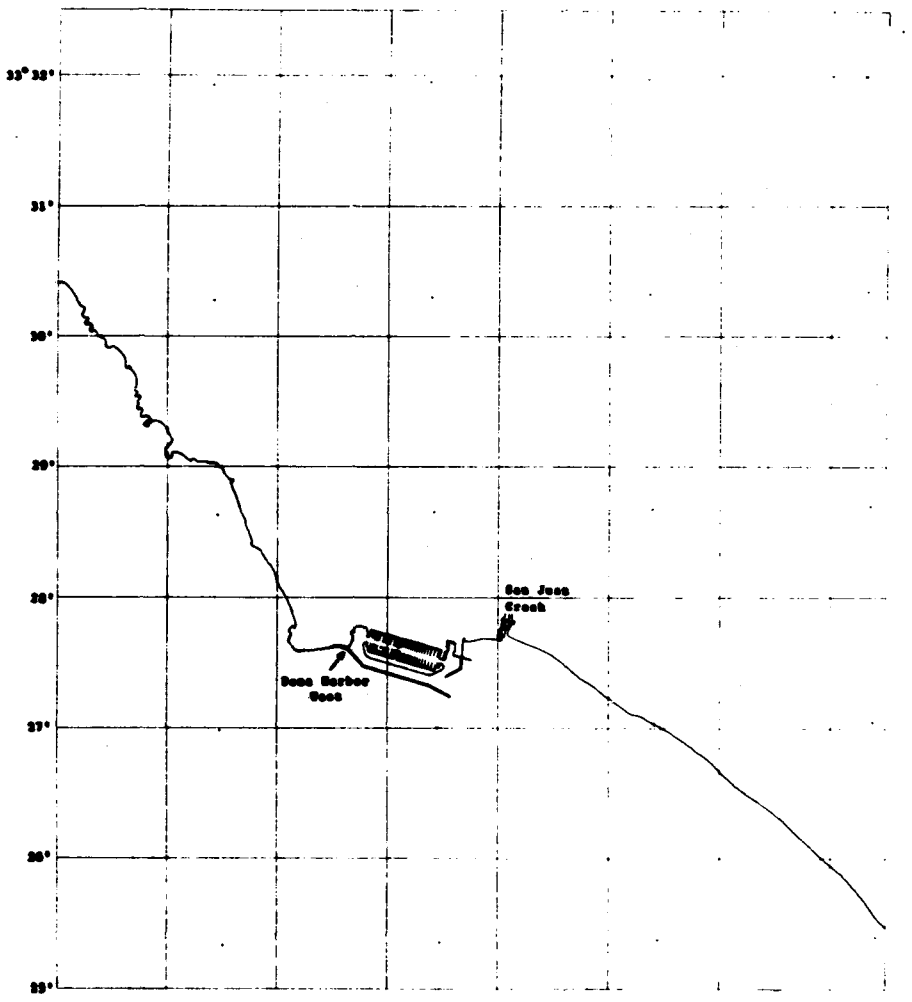

Figure 15. Map No. 10 - Dana Point/San Juan Capistrano

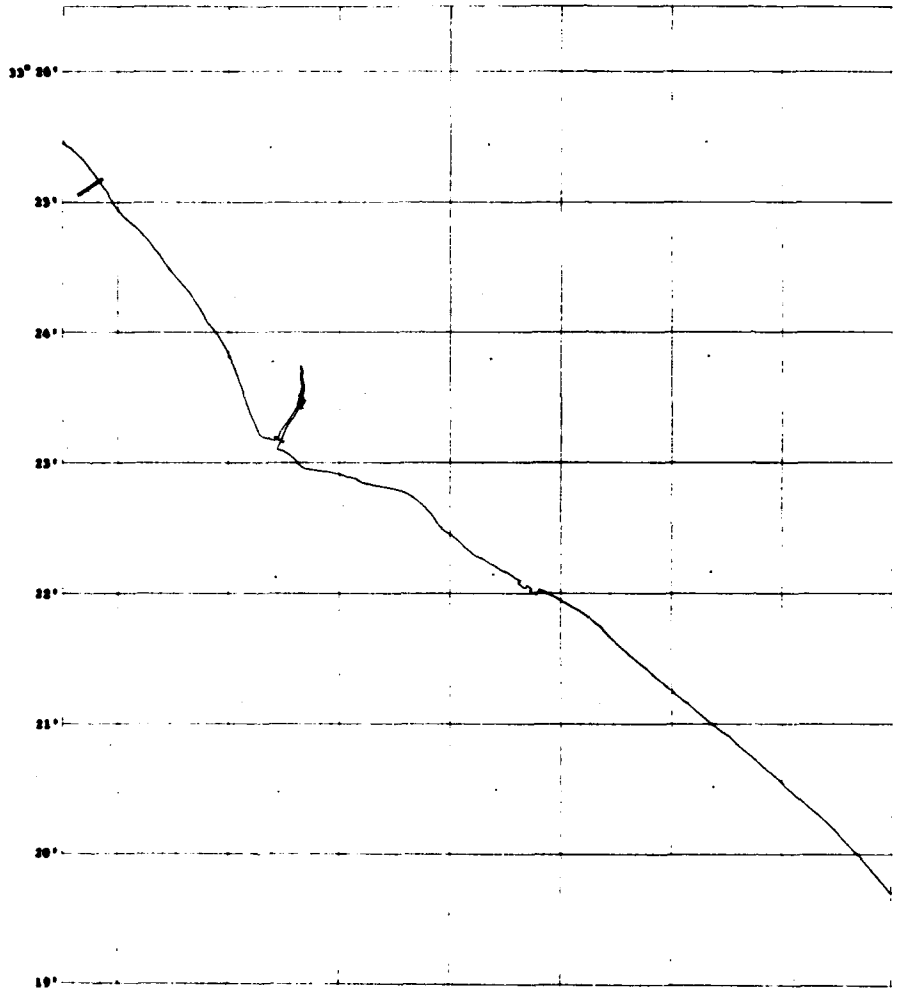

Figure 16. Map No. 9 - San Onofre' Bluff/San Clemente

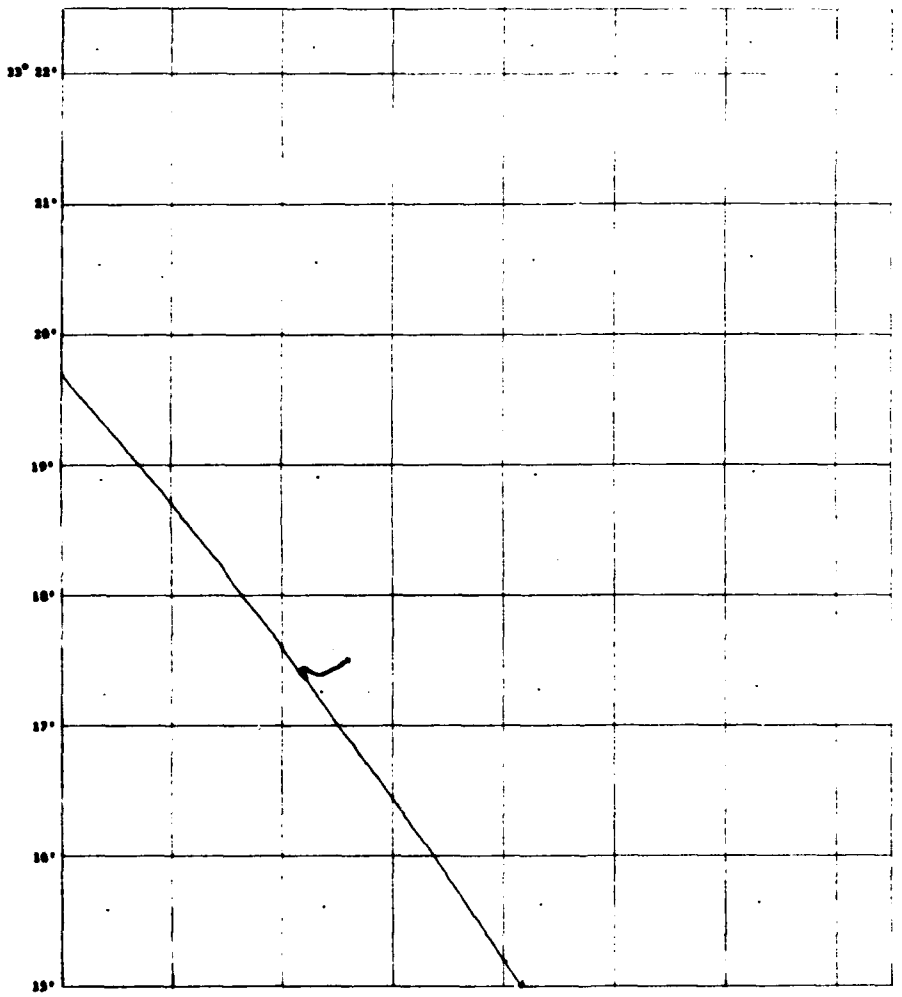

Figure 17. Map No. 8 - Las Pulgas Canyon

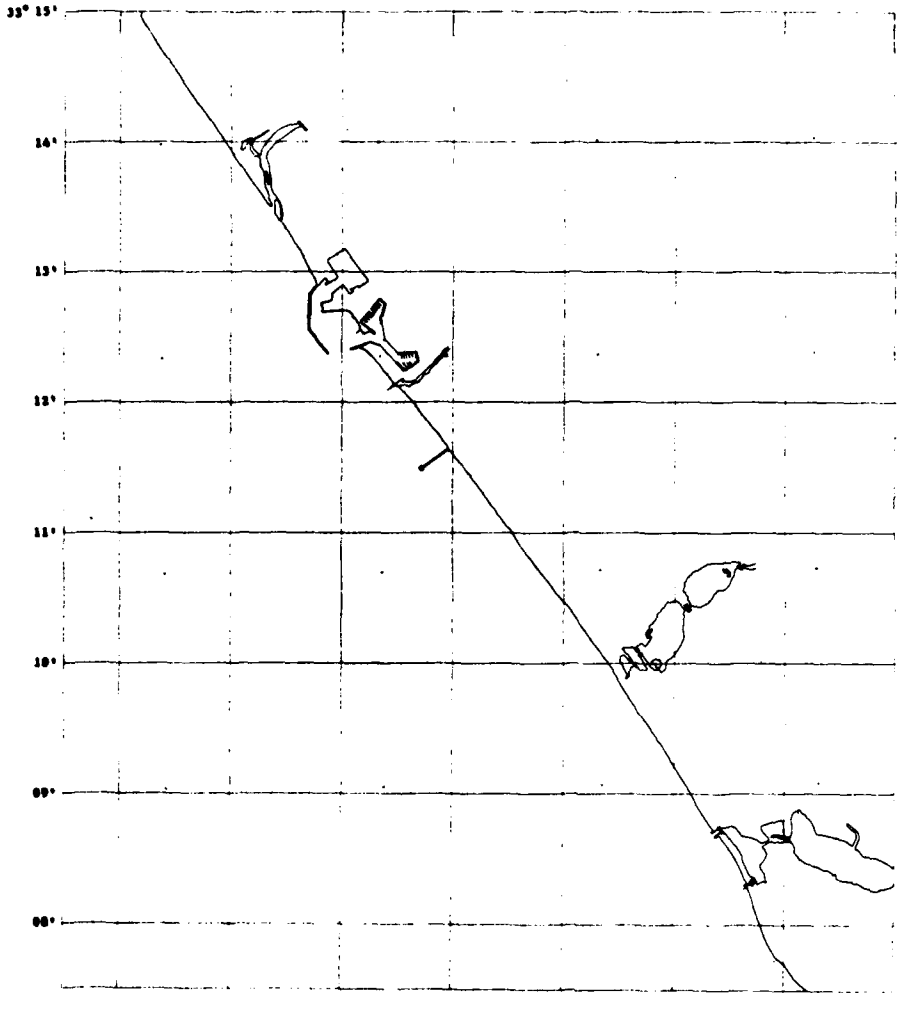

Figure 18. Map No. 7 - San Luis Rey/Oceanside

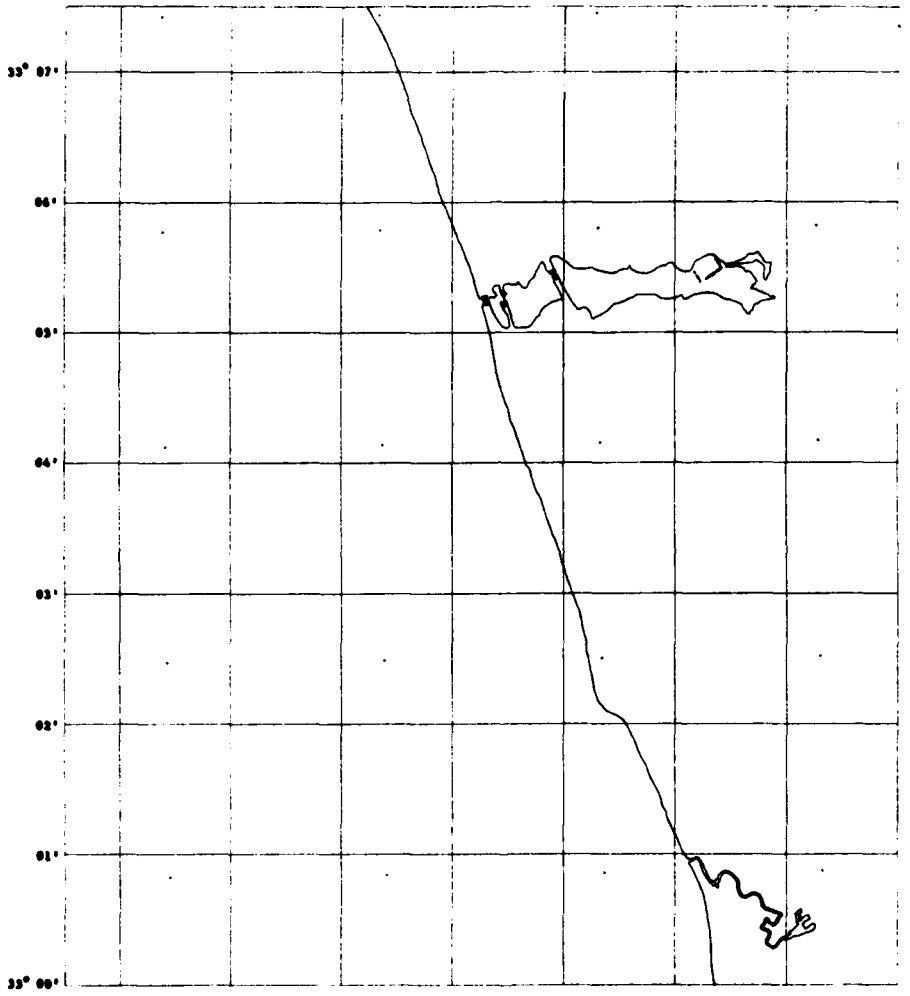

Figure 19. Map No. 6 - Encinitas

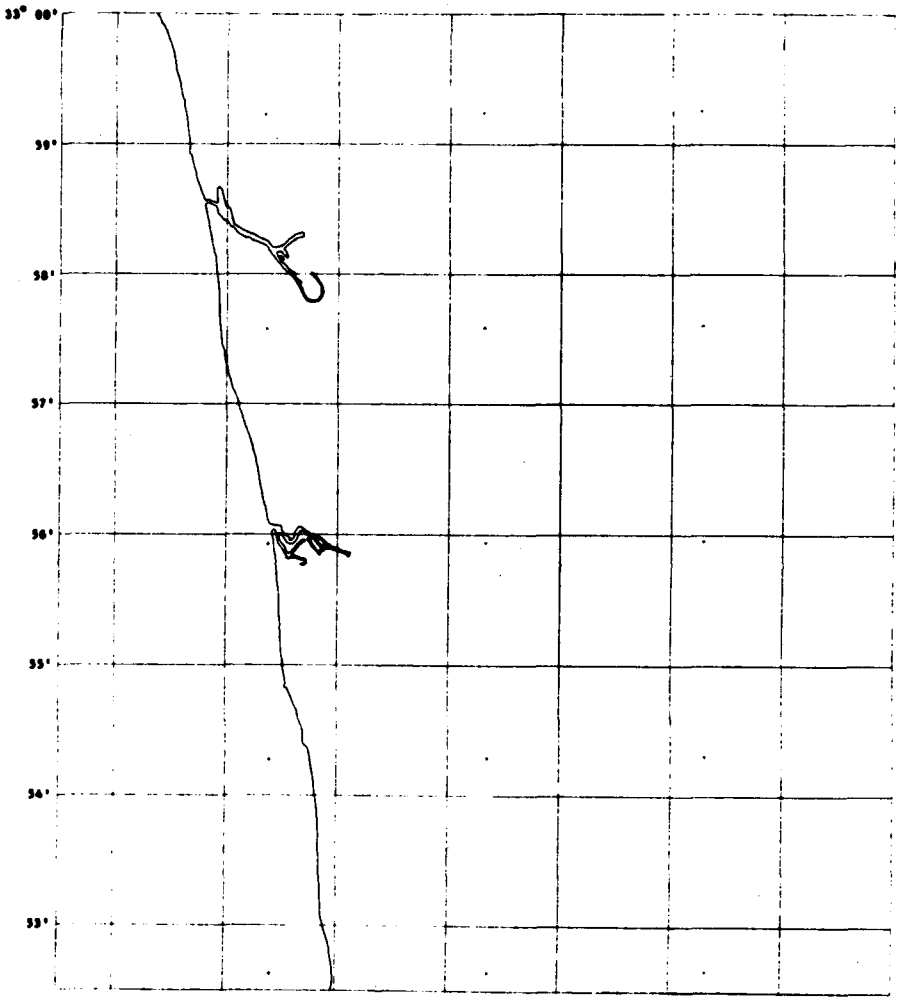

Figure 20. Map No. 5 - Del Mar

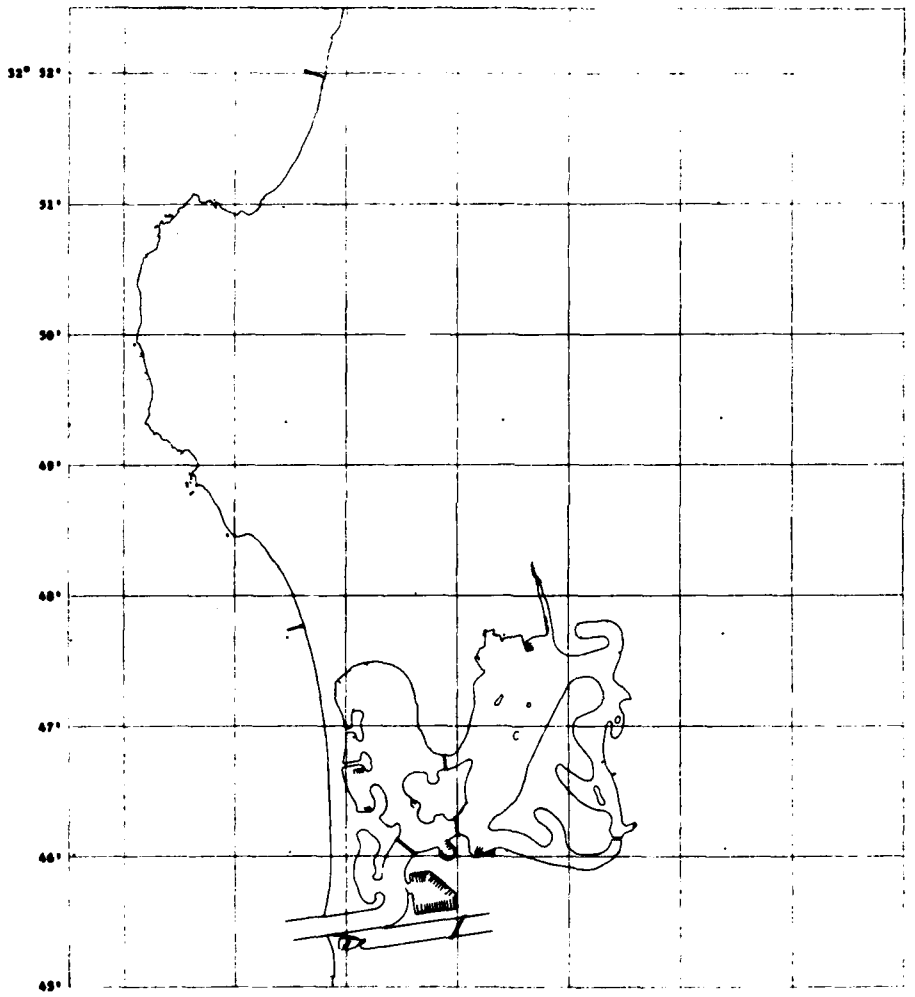

Figure 21. Map No. 4 - La Jolla

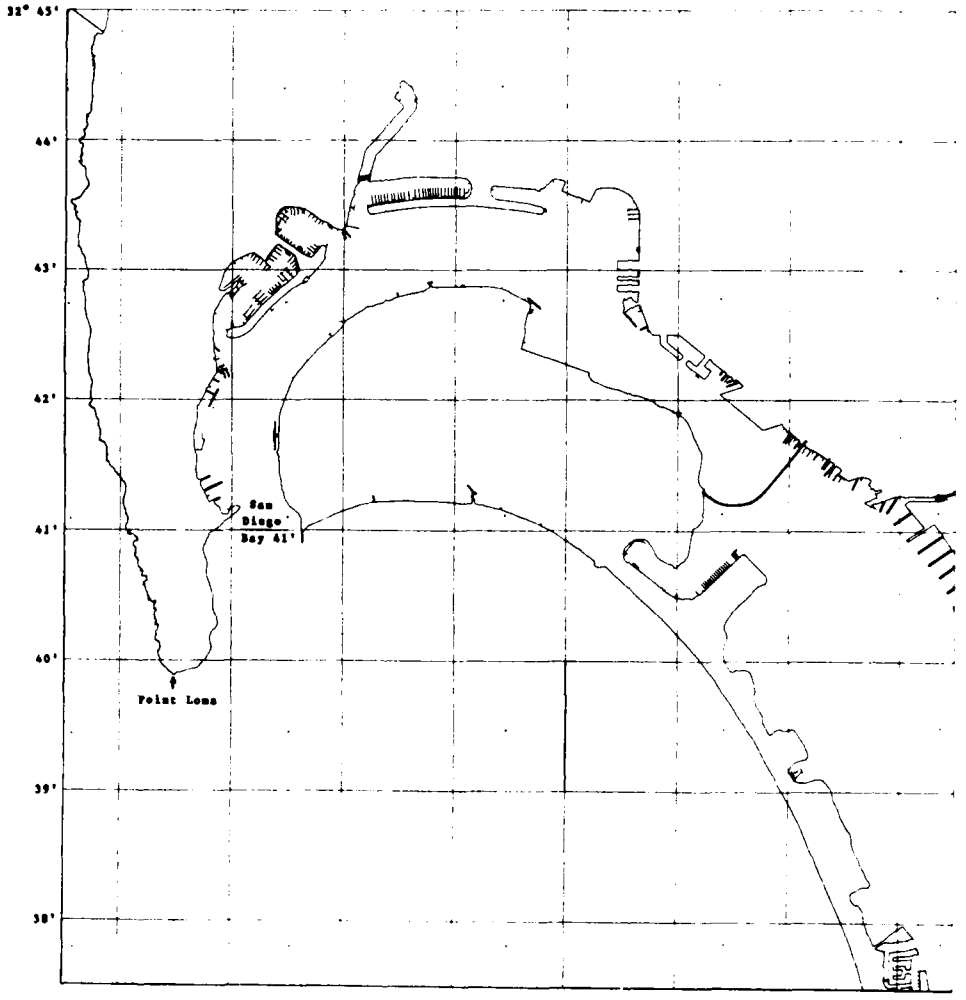

Figure 22. Map No. 3 - Point Loma

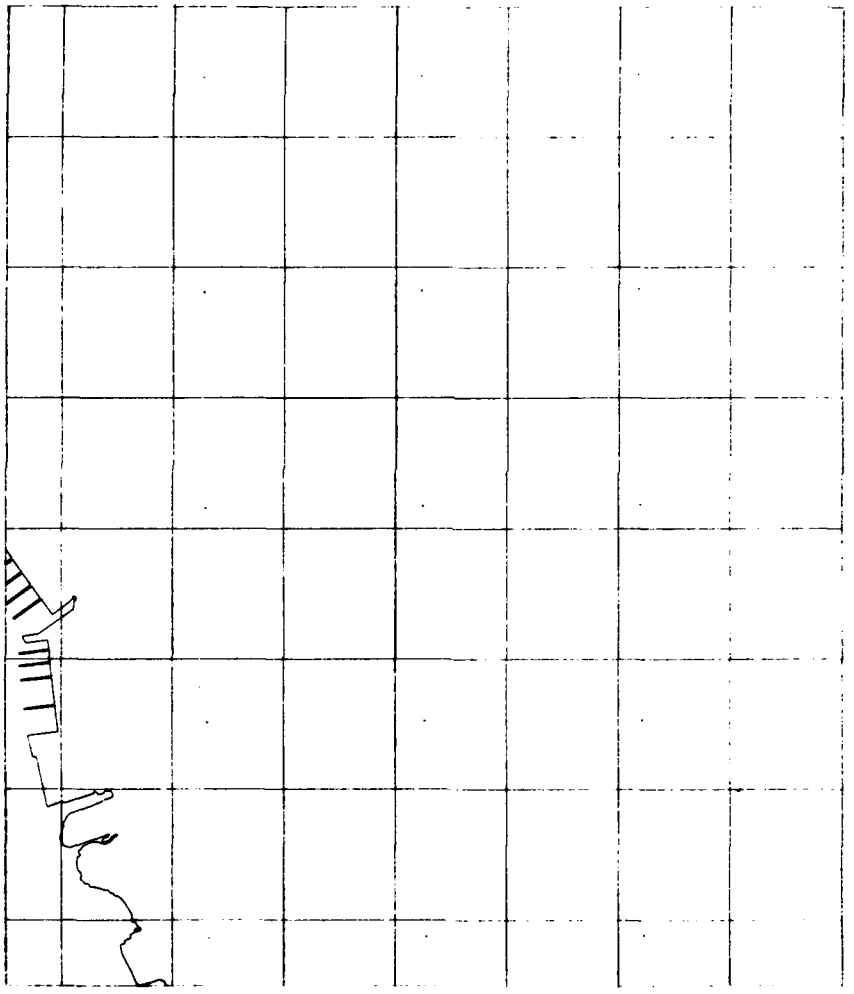

Figure 23. Map No. 2 - National City

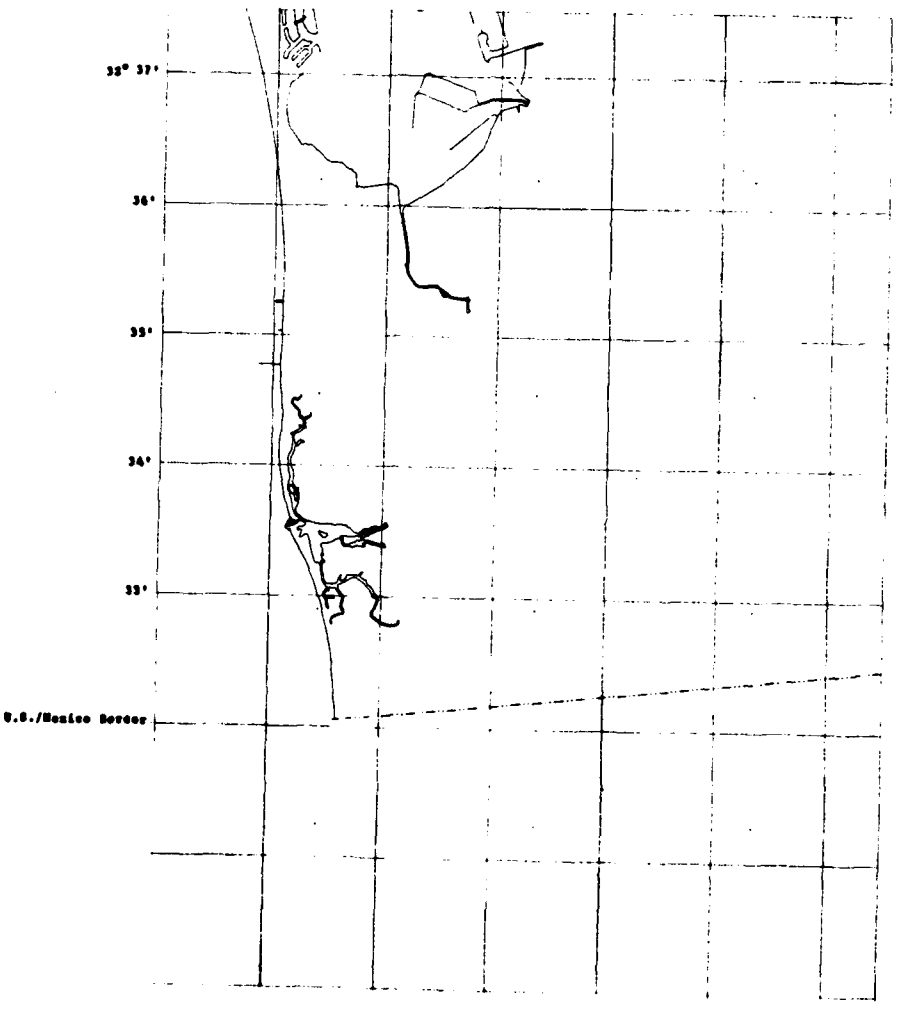

Figure 24. Map No. 1 - Imperial Beach

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SHORELINE MOVEMENT MAP

APPENDIX A: DATA SOURCES

This appendix specifies the basic survey and other data sources used in preparing the attached shoreline movement maps.

SUMMARY

Surveys Used - 127

Scales:

1:5,000	17
1:10,000	109
1:20,000	1
	127

Year Range: 1851 - 1974

IMPERIAL BEACH - 1:24,000

USGS base quad - Imperial Beach - Revision to USGS base quad from 1982 NOS photography.

Photo coverage: NOS 3/20/82, EC-9895-9898

HISTORICAL SURVEYS	YEAR	SCALE
T-364	1852	1:10,000
T-365	1852	1:10,000
T-1608	1887	1:10,000
T-3644	1916-17	1:10,000
T-5371	1933	1:10,000
T-11892	1960	1:10,000
T-11893	1960	1:10,000
T-11892(2)	1972	1:10,000
T-11893(2)	1972	1:10,000

NATIONAL CITY - 1:24,000

USGS base quad - National City - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9898-9895

HISTORICAL SURVEYS	YEAR	SCALE
T-364	1852	1:10,000
T-365	1852	1:10,000
T-1807	1887	1:10,000
T-1808	1887	1:10,000
T-3644	1916-17	1:10,000
T-5371	1933	1:10,000
T-5372	1933	1:10,000

POINT LOMA - 1:24,000

USGS base quad - Point Loma - Revision to the USGS base quad from 1982 NOS photography. The 1972 NOS survey was used to compile the 1982 line on the west side of Point Loma from Municipal Pier to Pt. Loma.

Photo Coverage: NOS 3/20/82, EC-9891-9895
NOS 3/20/82, EC-9899-9902

HISTORICAL SURVEYS	YEAR	SCALE
T-333	1851-52	1:10,000
T-363	1851-52	1:10,000
T-364	1851-52	1:10,000
T-1807	1887-89	1:10,000
T-1808	1887-89	1:10,000
T-2012	1887-89	1:10,000
T-2370	1898-99	1:10,000
T-3643	1916-17	1:10,000

T-3644	1916-17	1:10,000
T-4008	1923	1:10,000
T-5371	1933	1:10,000
T-5372	1933	1:10,000
T-5373	1933	1:10,000
T-5374	1933	1:10,000
T-11878	1960	1:10,000
T-11879	1960	1:10,000
T-11880	1960	1:10,000
T-11881	1960	1:10,000
T-11882	1960	1:10,000
T-11878(2)	1972	1:10,000
T-11879(2)	1972	1:10,000
T-11881(2)	1972	1:10,000
T-11882(2)	1972	1:10,000

LA JOLLA - 1:24,000

USGS base quad - La Jolla - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 3/20/82, EC-9887-9891
NOS 3/20/82, EC-9902-9906

HISTORICAL SURVEYS	YEAR	SCALE
T-363	1852	1:10,000
T-2013	1889	1:10,000
T-2014	1889	1:10,000
T-4009	1922	1:10,000
T-5374	1933	1:10,000
T-5375	1933	1:10,000
T-11876	1960	1:10,000
T-11877	1960	1:10,000

T-11876(2)	1972	1:10,000
T-11877(2)	1972	1:10,000

DEL MAR - 1:24,000

USGS base quad - Del Mar - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9907-9910

HISTORICAL SURVEYS	YEAR	SCALE
T-1889	1887-88	1:10,000
T-2014	1889	1:10,000
T-5375	1933-34	1:10,000
T-5410	1933-34	1:10,000
T-11874	1960	1:10,000
T-11875	1960	1:10,000
T-11874(2)	1972	1:10,000
T-11875(2)	1972	1:10,000

ENCINITAS - 1:24,000

USGS base quad - Encintias - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9910-9911
NOS 3/20/82, EC-9912-9915

HISTORICAL SURVEYS	YEAR	SCALE
T-1898	1887-88	1:10,000
T-1899	1887-88	1:10,000
T-5411	1934	1:10,000
T-5412	1934	1:10,000
T-11872	1960	1:10,000
T-11873	1960	1:10,000
T-11872(2)	1972	1:10,000
T-11873(2)	1972	1:10,000

SAN LUIS REY/OCEANSIDE - 1:24,000

USGS base quad - San Luis Rey, Oceanside - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9907-9920

HISTORICAL SURVEYS	YEAR	SCALE
T-1889	1887-88	1:10,000
T-1900	1887-88	1:10,000
T-5412	1934	1:10,000
T-5413	1934	1:10,000
T-11870	1960	1:10,000
T-11871	1960	1:10,000
T-11870(2)	1972	1:10,000
T-11871(2)	1972	1:10,000

LUS PULGAS CANYON - 1:24,000

USGS base quad - Lus Pulgas Canyon - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9920-9923
NOS 3/20/82, EC-9929-9932

HISTORICAL SURVEYS	YEAR	SCALE
T-1900	1887-89	1:10,000
T-2015	1887-89	1:10,000
T-5413	1934	1:10,000
T-5414	1934	1:10,000
T-11868	1960	1:10,000
T-11869	1960	1:10,000
T-11868(2)	1972	1:10,000
T-11869(2)	1972	1:10,000

SAN ONOFRE BLUFF/SAN CLEMENTE - 1:24,000

USGS base quad - San Onofre Bluff, San Clemente - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 3/20/82, EC-9923-9927
NOS 3/20/82, EC-9932-9936

HISTORICAL SURVEYS	YEAR	SCALE
T-2015	1889	1:10,000
T-2016	1889	1:10,000
T-5414	1934	1:10,000
T-5415	1934	1:10,000
T-5416	1934	1:10,000
T-11866	1960	1:10,000
T-11867	1960	1:10,000
T-11866(2)	1972	1:10,000
T-11867(2)	1972	1:10,000

DANA POINT/SAN JUAN CAPISTRANO - 1:24,000

USGS base quad - Dana Point, San Juan Capistrana - Revision to USGS base quad from 1982 NOS photography. At Dana Point, the 1982 line was changed to match the NOS 1972 survey.

Photo Coverage NOS 3/20/82, EC-9927-9928
NOS 3/20/82, EC-9936-9939

HISTORICAL SURVEYS	YEAR	SCALE
T-5416	1934	1:10,000
T-5417	1934	1:10,000
T-11658	1959-60	1:10,000
T-11659	1959-60	1:10,000
T-11864	1959-60	1:10,000
T-11864(2)	1971-72	1:10,000
T-11865(2)	1971-72	1:10,000
T-00414	1971-72	1:10,000

T-00415	1971-72	1:10,000

LAGUNA BEACH - 1:24,000

USGS base quad - Laguna Beach - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 3/20/82, EC-9939-9943

HISTORICAL SURVEYS	YEAR	SCALE
T-1392	1875	1:10,000
T-1646	1885	1:10,000
T-5186	1926	1:10,000
T-5417	1934	1:10,000
T-5418	1934	1:10,000
T-11655	1959	1:10,000
T-11656	1959	1:10,000
T-11657	1959	1:10,000
T-00411	1971	1:5,000
T-00412	1971	1:10,000
T-00413	1971	1:10,000

NEWPORT BEACH - 1:24,000

USGS base quad - Newport Beach - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 3/20/82, EC-9947

HISTORICAL SURVEYS	YEAR	SCALE
T-1369	1874-75	1:10,000
T-1392	1874-75	1:10,000
T-4186	1926	1:10,000
T-11651	1959	1:10,000
T-11652	1959	1:10,000
T-11653	1959	1:10,000
T-11654	1959	1:10,000

T-00406	1971	1:5,000
T-00407	1971	1:5,000
T-00408	1971	1:5,000
T=00409	1971	1:5,000
T-00410	1971	1:5,000

SEAL BEACH/LOS ALAMITOS - 1:24,000

USGS base quad - Seal Beach, Los Alamitos - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 3/20/82, EC-9947-9951

HISTORICAL SURVEYS	YEAR	SCALE
T-1369	1873-74	1:10,000
T-3819	1820	1:10,000
T-11643	1959	1:10,000
T-11648	1959	1:10,000
T-11649	1959	1:10,000
T-11650	1959	1:10,000
T-00396	1971-72	1:5,000
T-00403	1971-72	1:5,000
T-00404	1971-72	1:10,000
T-00405	1971-72	1:10,000

LONG BEACH 1-24,000

USGS base quad - Long Beach - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage: NOS 3/20/82, EC-9951-9952
NOS 11/20/82, BC-0631-0632

HISTORICAL SURVEYS	YEAR	SCALE
T-892	1859	1:10,000
T-1283	1872	1:10,000
T-3819	1920	1:10,000

T-3820	1920	1:10,000
T-11641	1959	1:10,000
T-11642	1959	1:10,000
T-11647	1959	1:10,000
T-11648	1959	1:10,000
T-00393	1972	1:5,000
T-00394	1972	1:5,000
T-00395	1972	1:5,000
T-00400	1972	1:5,000
T-00401	1972	1:5,000
T-00402	1974	1:5,000

TORRANCE/SAN PEDRO - 1:24,000

USGS base quad - Torrance, San Pedro - Revision to USGS base quad from 1982 NOS photography.
Photo Coverage NOS 11/25/82, BC-0623, 0632-0633

HISTORICAL SURVEYS	YEAR	SCALE
T-892	1859	1:10,000
T-1153	1870	1:10,000
T-2365	1899	1:10,000
T-3098	1910	1:10,000
T-3820	1920	1:10,000
T-11640	1959	1:10,000
T-11645	1959	1:10,000
T-11646	1959	1:10,000
T-00392	1972	1:5,000
T-00397	1972	1:10,000
T-00398	1972	1:5,000
T-00399	1972	1:5,000

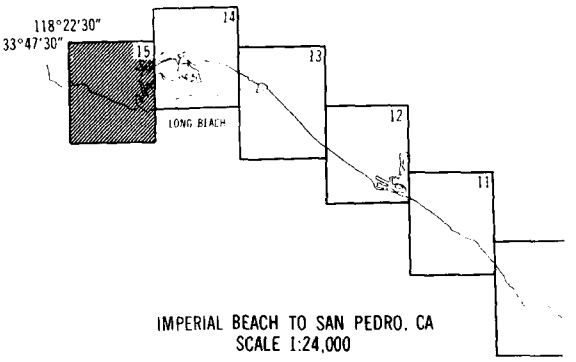
NOAA/N
SHO
Imp

118°22'30"
33°47'30"

20'

NOS - LAD COOPERATIVE SH
MAPPING PRO

INDEX TO ADJOINI



IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

45'

Portuguese Bend

Portuguese
Point

US Army Corps
of Engineers
Los Angeles District

A/NOS - COE/LAD COOPERATIVE
HORELINE MOVEMENT STUDY
Imperial Beach - San Pedro, CA

17'

USE OF SHORELINE MOVEMENT MAP

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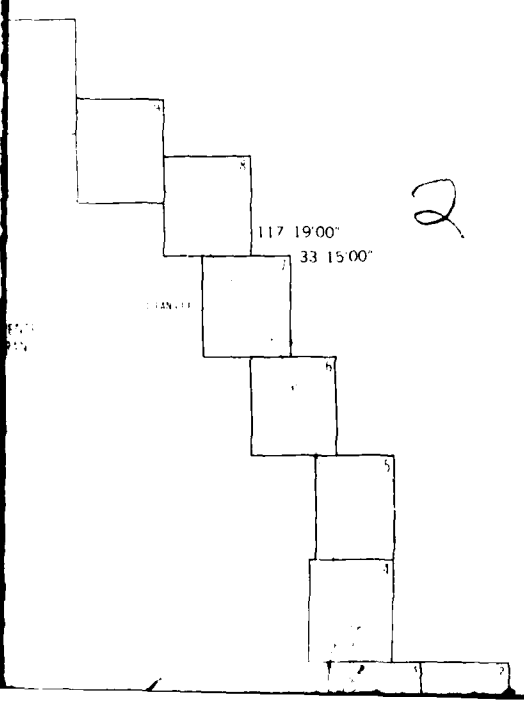
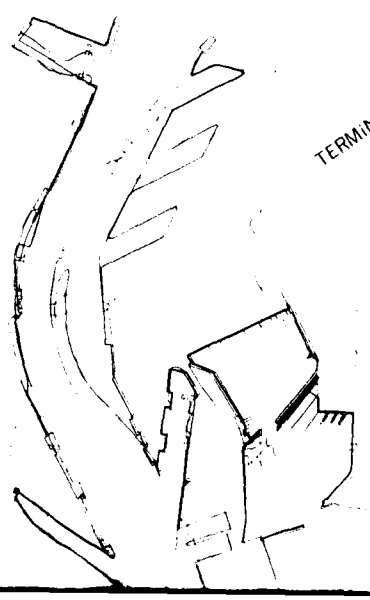
HORELINE MOVEMENT
PROGRAM

SHEETS



SAN PEDRO



E

17'

118 15' 00"
33 47' 30"

USE OF SHORELINE MOVEMENT MAP

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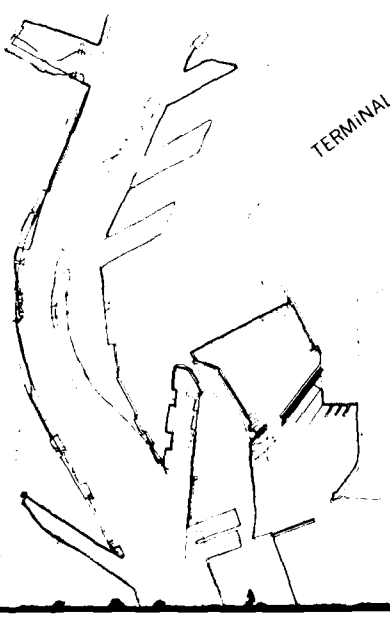
45'

TERMINAL ISLAND

3

SAN PEDRO



42'

LEGEND
(Source of Mean High Water Line)

- November 1982 NOS Aerial Photography
- 1972 Field Survey
- 1959 Field Survey
- 1920 Field Survey
- 1910 Field Survey
- 1899 Field Survey
- 1870 Field Survey
- 1859 Field Survey

33°40'00"
118°22'30"

20'

1000

Prepared by the National Ocean Service, as part of a cooperative program with the Los Angeles District, U.S. Army Corps of Engineers. Compiled from registered historical shoreline surveys of the National Ocean Service, and registered to base maps furnished by the U.S. Geological Survey (USGS). The area of this map generally corresponds to the U.S.G.S. quadrangle of the same name. 1982 shoreline compiled from aerial photography taken 1982.

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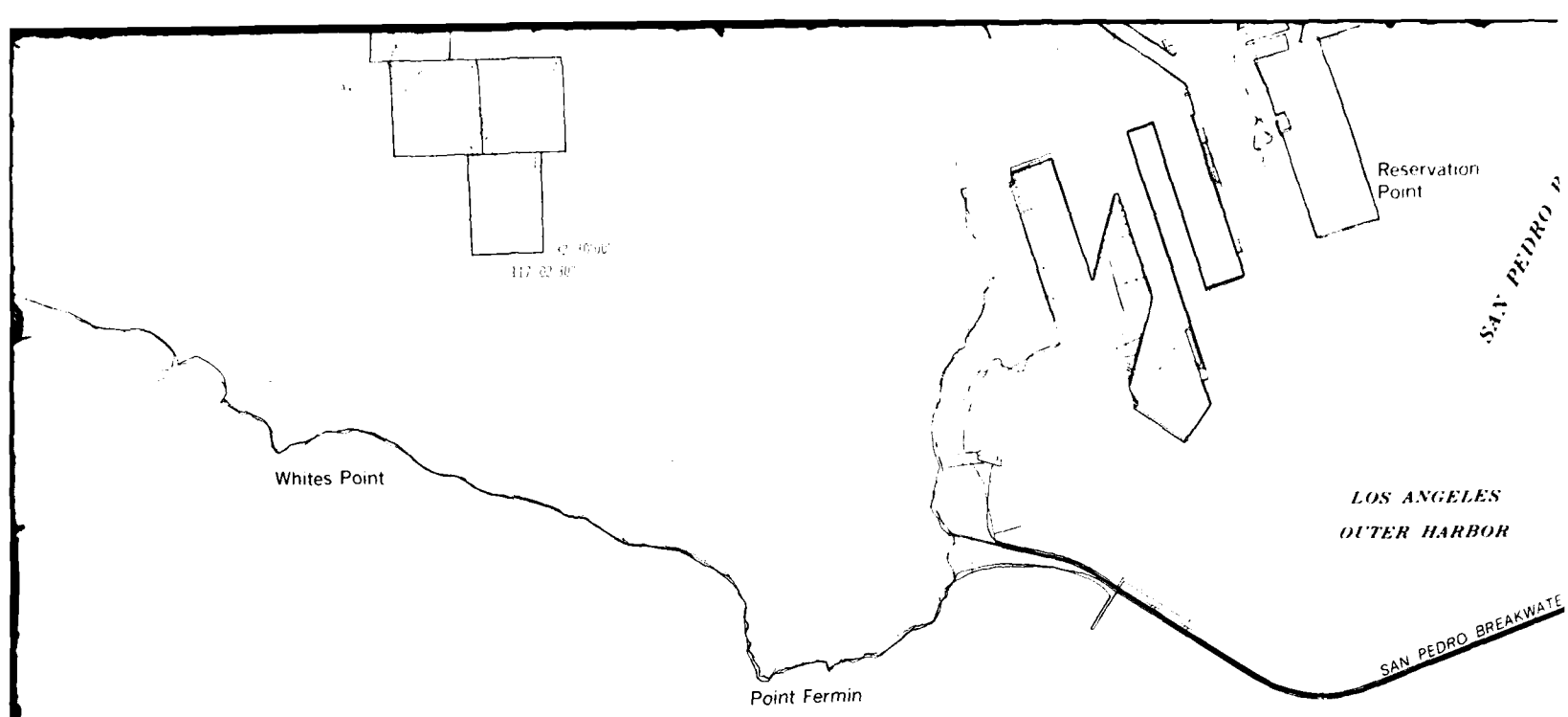
NATIO



OCEAN

SCALE 1 24 000

MILE 0 1

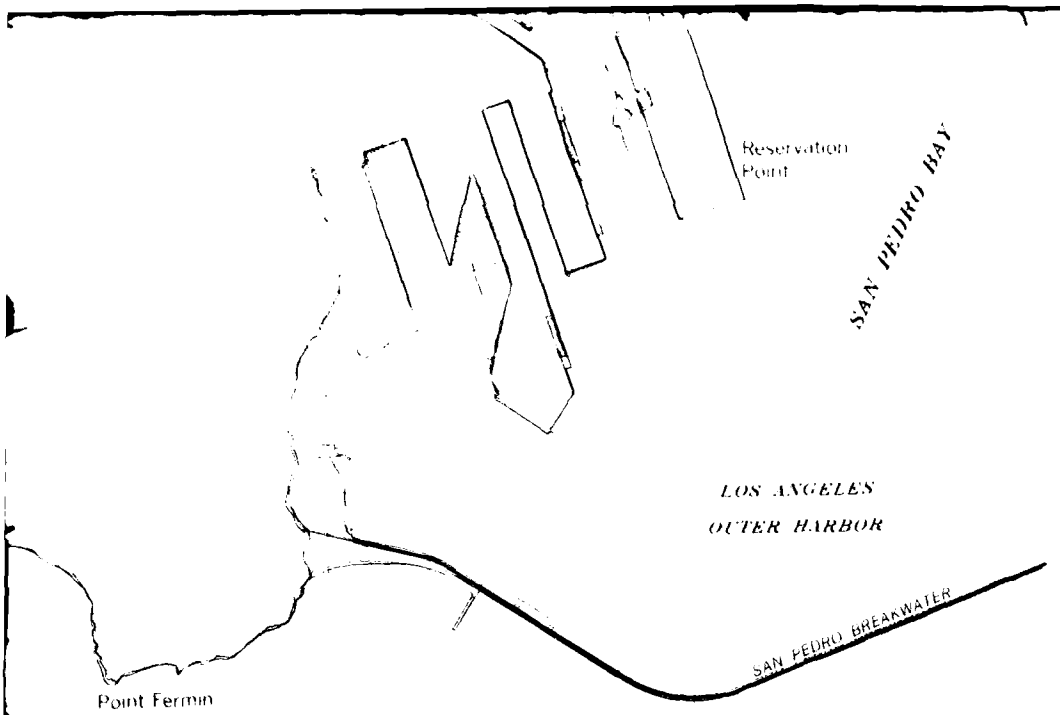
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

KILOMETRE 1 5 0 1

1927 NORTH AMERICAN DATUM
POLYCONIC PROJECTION

Published at Washington, D C
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

TORRANCE/SAN PE



42

33 40'00"
118°15'00"

R5859

17'

TORRANCE/SAN PEDRO, CA.

NOAA/NOS - COE/LA
SHORELINE MOV
Imperial Beach -

118 15'00"
33 50'00"

13'

48'

USE OF SHORELINE MOVEMENT MAP

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LEGEND
(Source of Mean High Water Line)

———— March, November 1982 NOS Aerial Photography
1972 Field Survey
1959 Field Survey
- - - - 1920 Field Survey
1872 Field Survey
1859 Field Survey

LOS ANGELES RIVER

US Army Corps
of Engineers
Los Angeles District

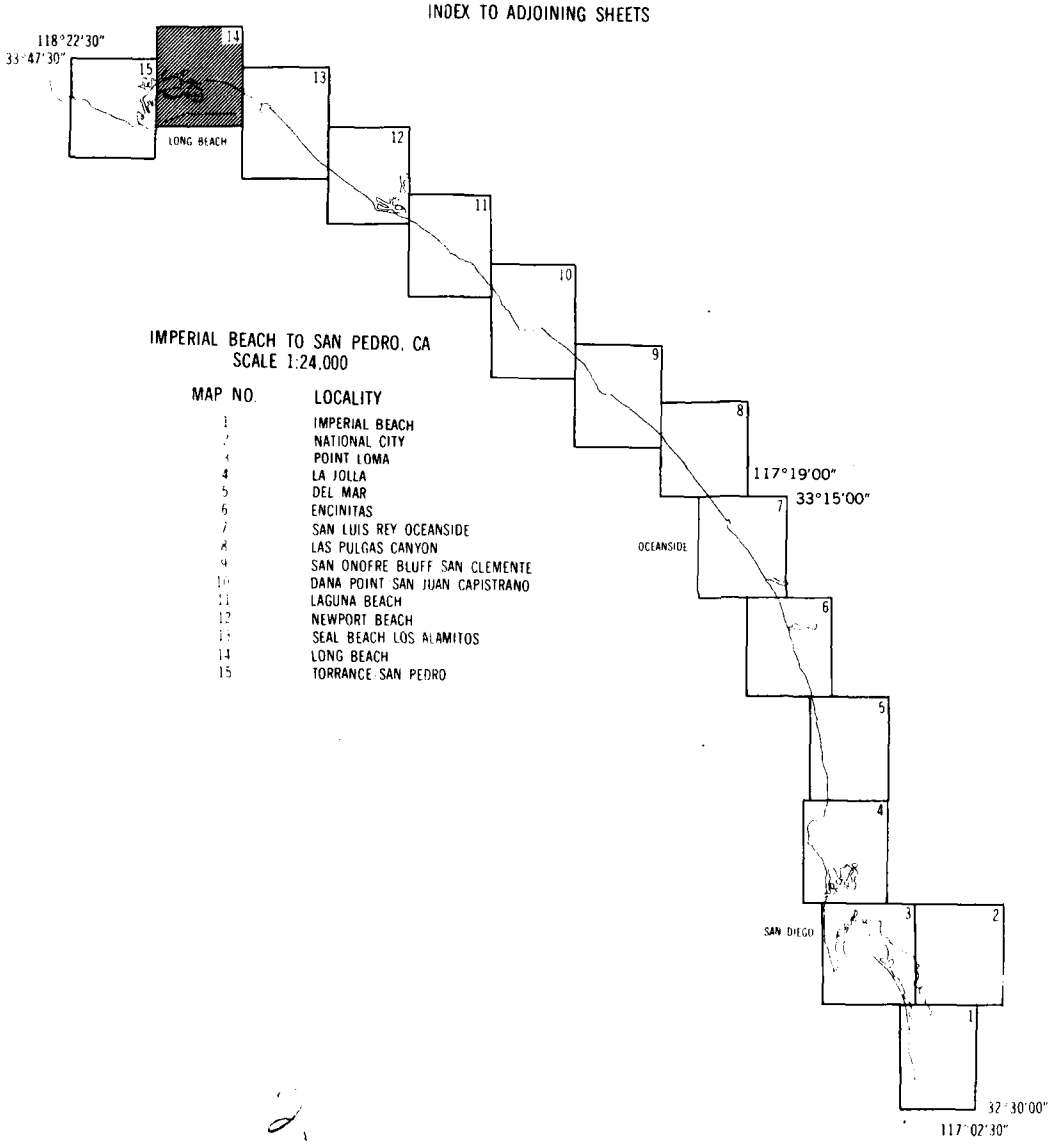
AD COOPERATIVE
EMENT STUDY
San Pedro, CA

10'

118°07'30"
33°50'00"

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

INDEX TO ADJOINING SHEETS

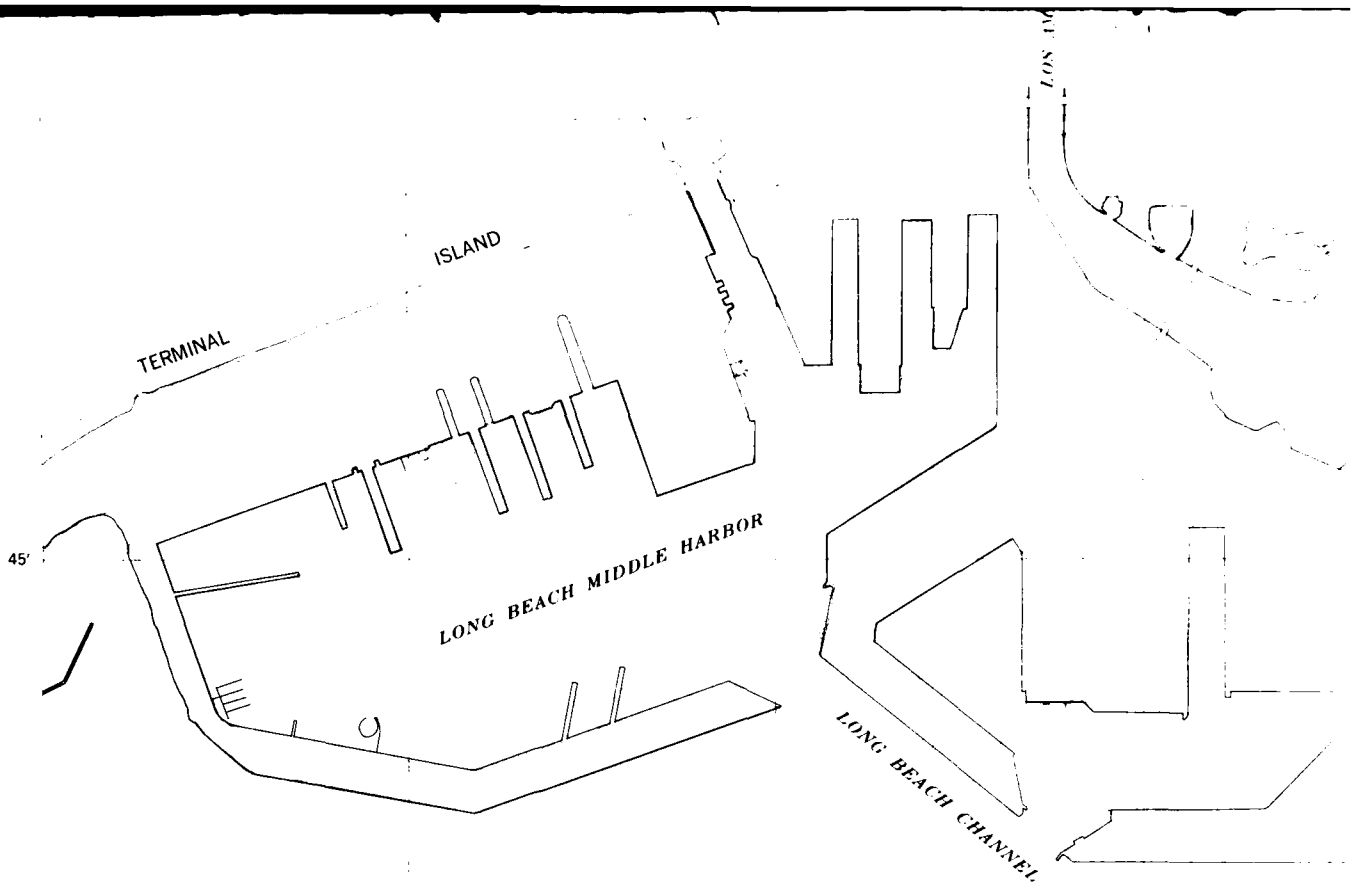


IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF SAN CLEMENTE
10	DANA POINT SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH LOS ALAMITOS
14	LONG BEACH
15	TORRANCE SAN PEDRO

48'

LONG BEACH



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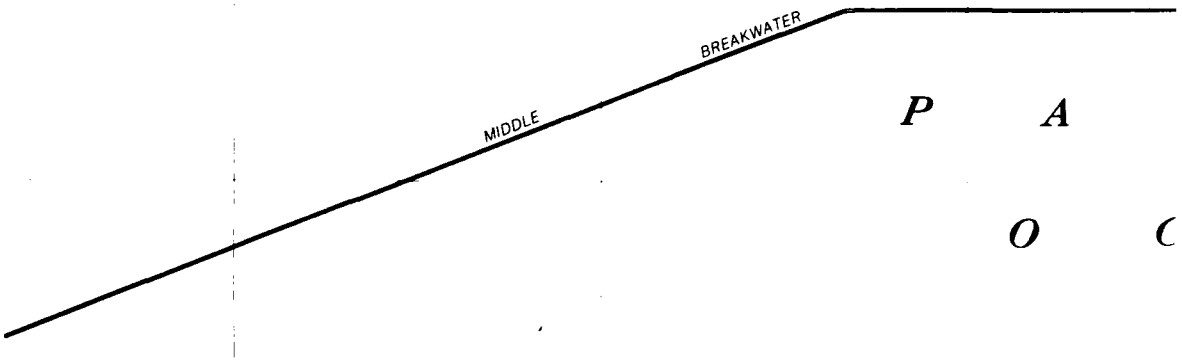

P A

O C

33°42'30"
118°15'00"

13'

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1000 0 1000

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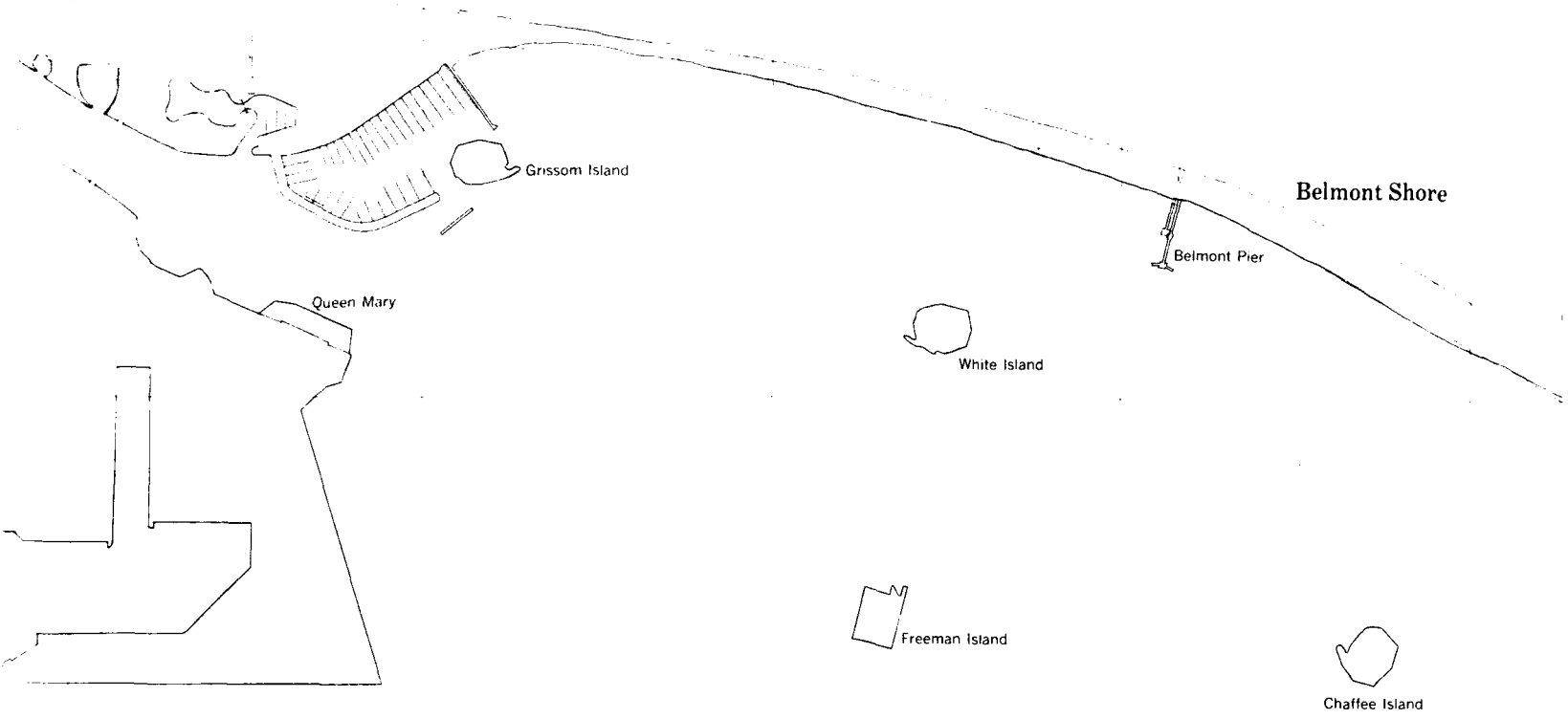
NATIO



LONG BEACH BREAKWATER

P A C I F I C

O C E A N

10'

R58581

SCALE 1:24 000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 5 0 1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

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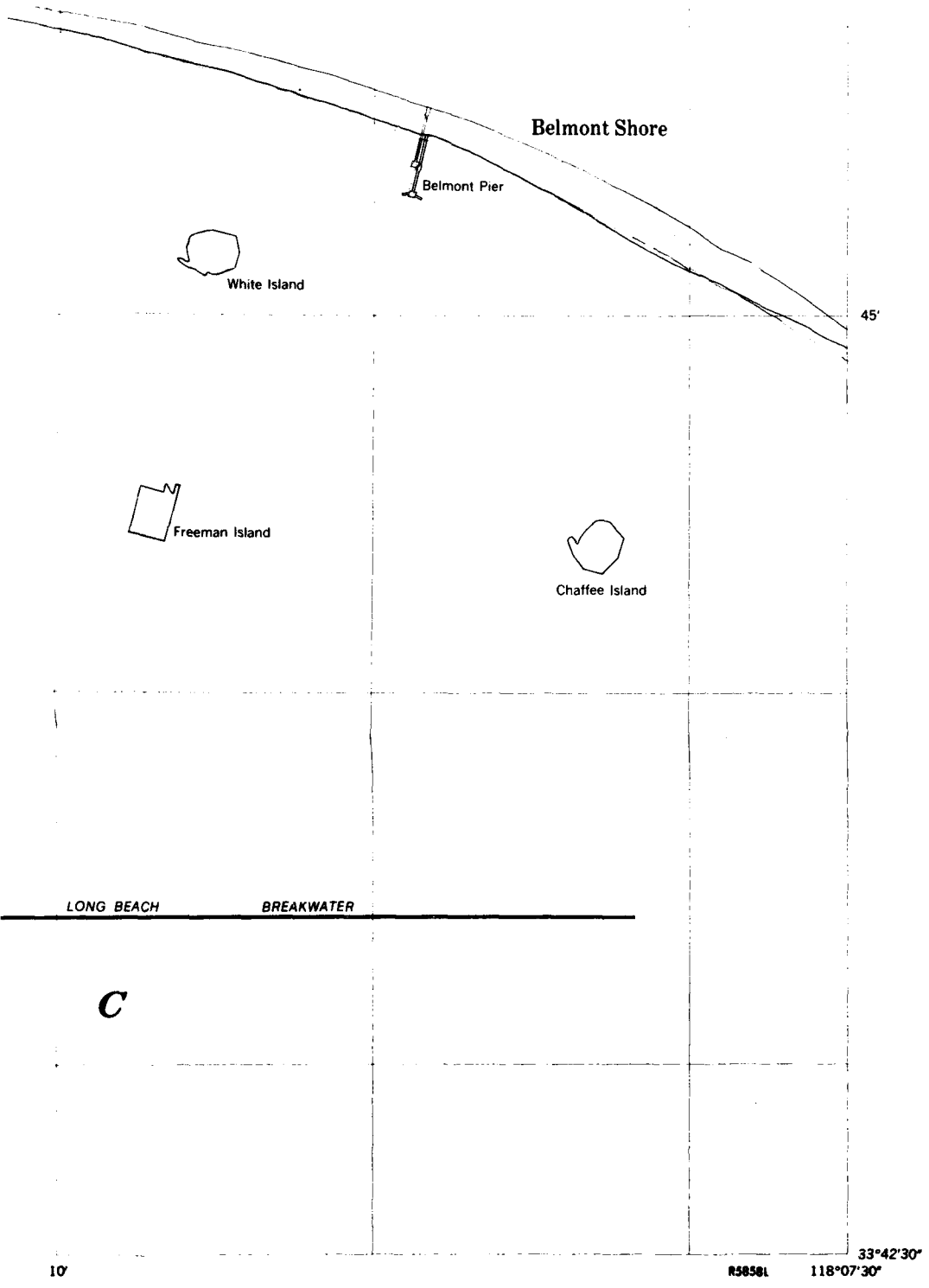
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

LONG BEAC

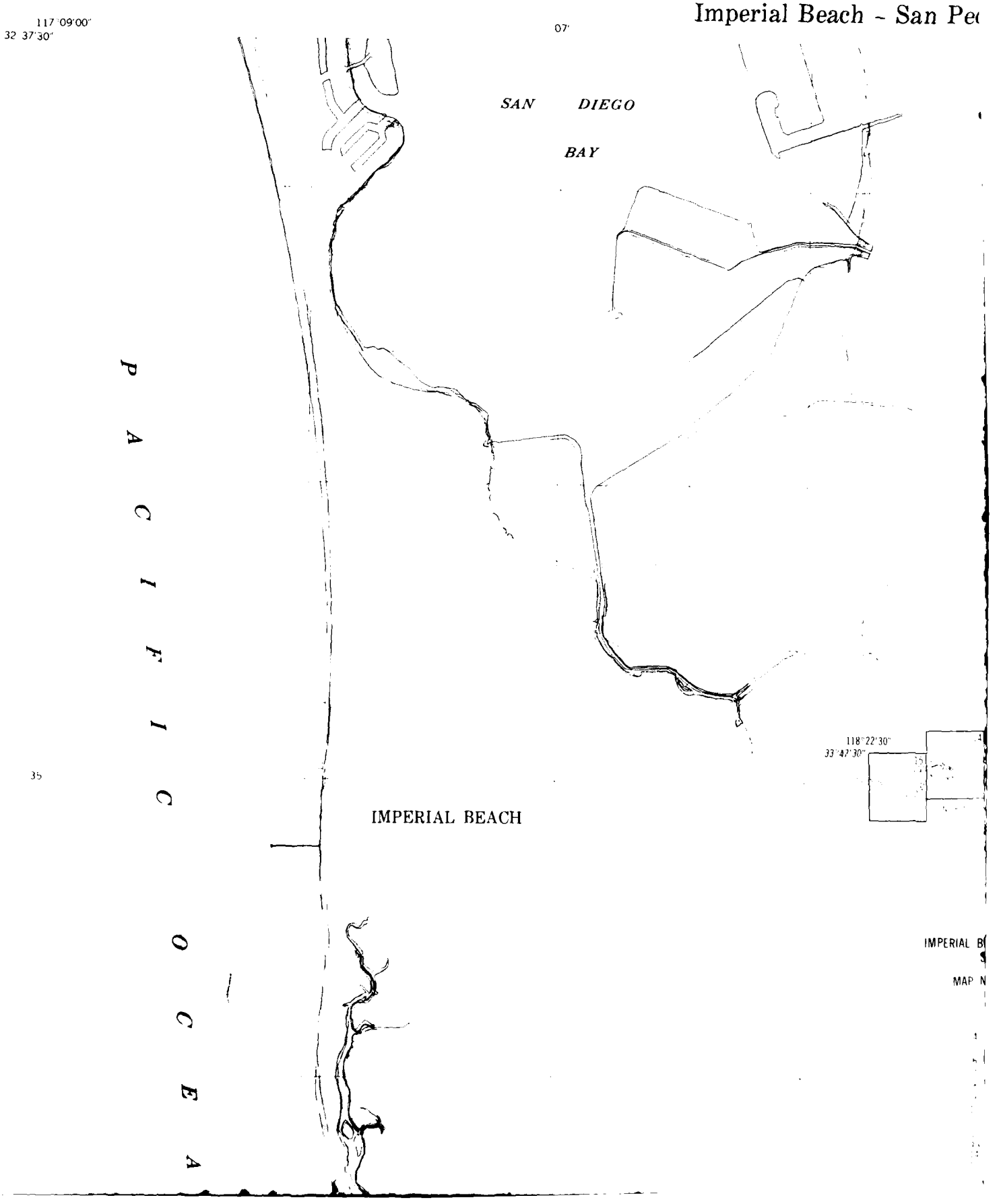


LONG BEACH, CA.

6

US Army
of Engin
Los Angele

NOAA/NOS - COE/LAD COC
SHORELINE MOVEMENT
Imperial Beach - San Pe



IMPERIAL B

MAP N

US Army Corps
of Engineers
Los Angeles District

- COE/LAD COOPERATIVE
INE MOVEMENT STUDY
l Beach - San Pedro, CA

05'

117°02'30"
32°37'30"

CHULA VISTA

USE OF SHORELINE MOVEMENT MAP

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NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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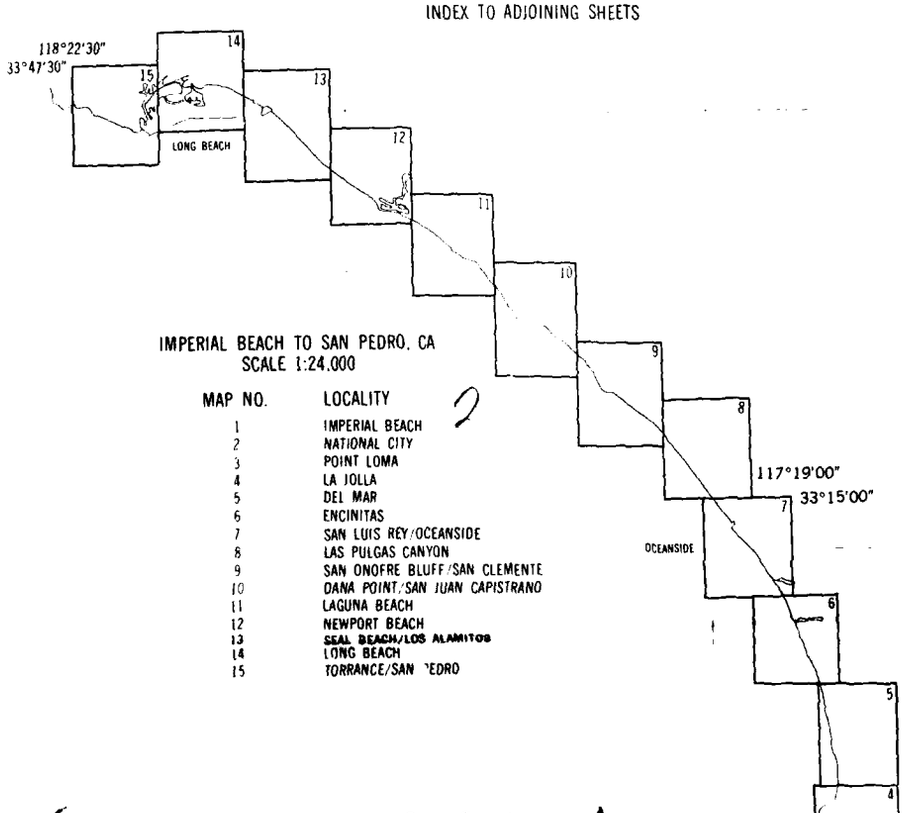
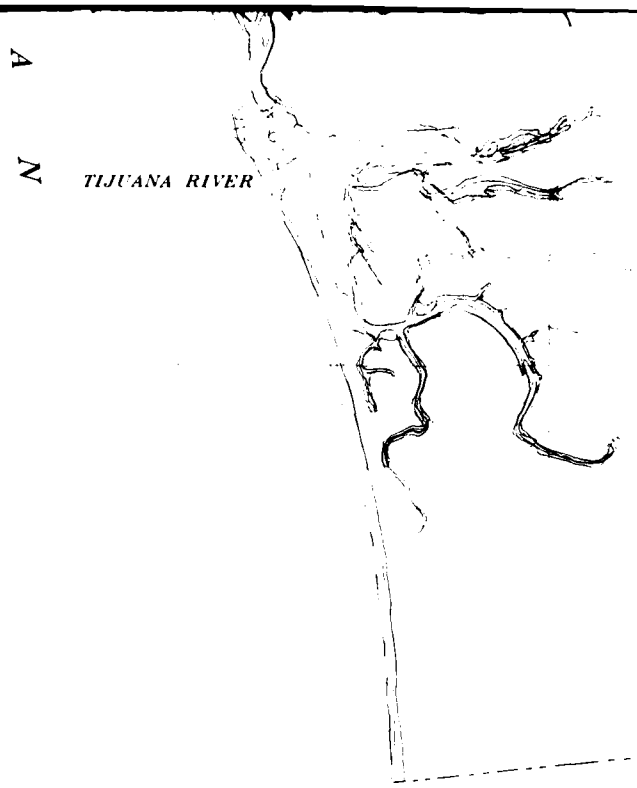


35'

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO



32'

LEGEND
(Source of Mean High Water Line)

——— March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1933 Field Survey
1916/17 Field Survey
1887 Field Survey
1852 Field Survey

32°30'00"
117°09'00"

07'

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SCALE 1 24 000

1000 0 1000 2000 3000 4000

1927 NORTH AMERICAN DATI
LAMBERT PROJECTION

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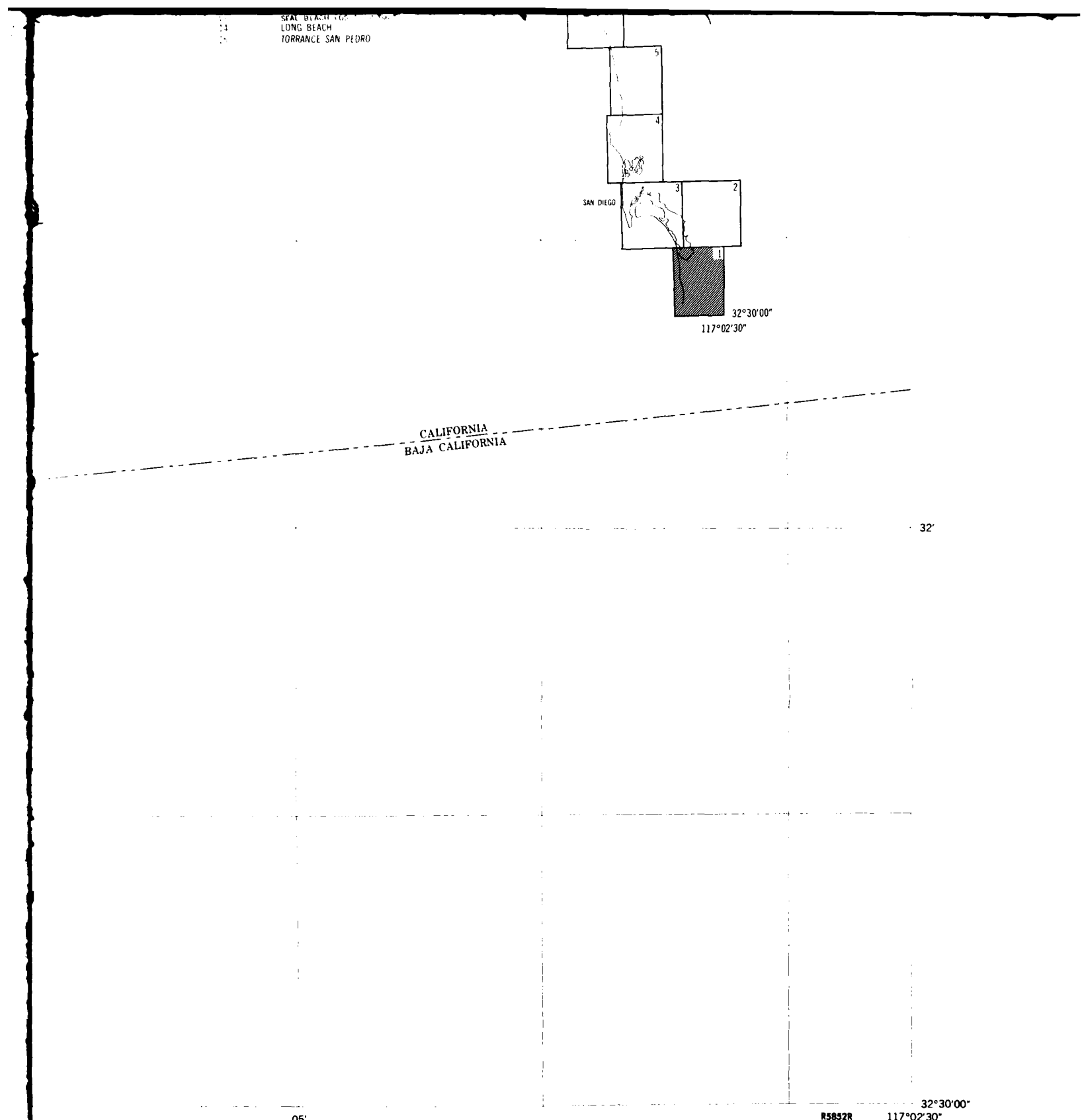
U.S. DEPARTMENT OF COM
NATIONAL OCEANIC AND ATMOSPHERI
NATIONAL OCEAN SERV



SCALE 1:24 000

0 1 MILE

2000 3000 4000 5000 6000 7000 FEET

0 1 KILOMETRE

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LAMBERT PROJECTION

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

5'

IMPERIAL BEACH, CA.

NOAA/NOS - CO
SHORELINE
Imperial Bea

117°07'30"
32°45'00"

05'

SAN DIEGO

43'

Los Angeles District

LAD COOPERATIVE VEMENT STUDY - San Pedro, CA

02'

117°00'00"
32°45'00"

USE OF SHORELINE MOVEMENT MAP

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NOS - LAD COOPERATIVE SHORELINE MOVEMENT MAPPING PROGRAM

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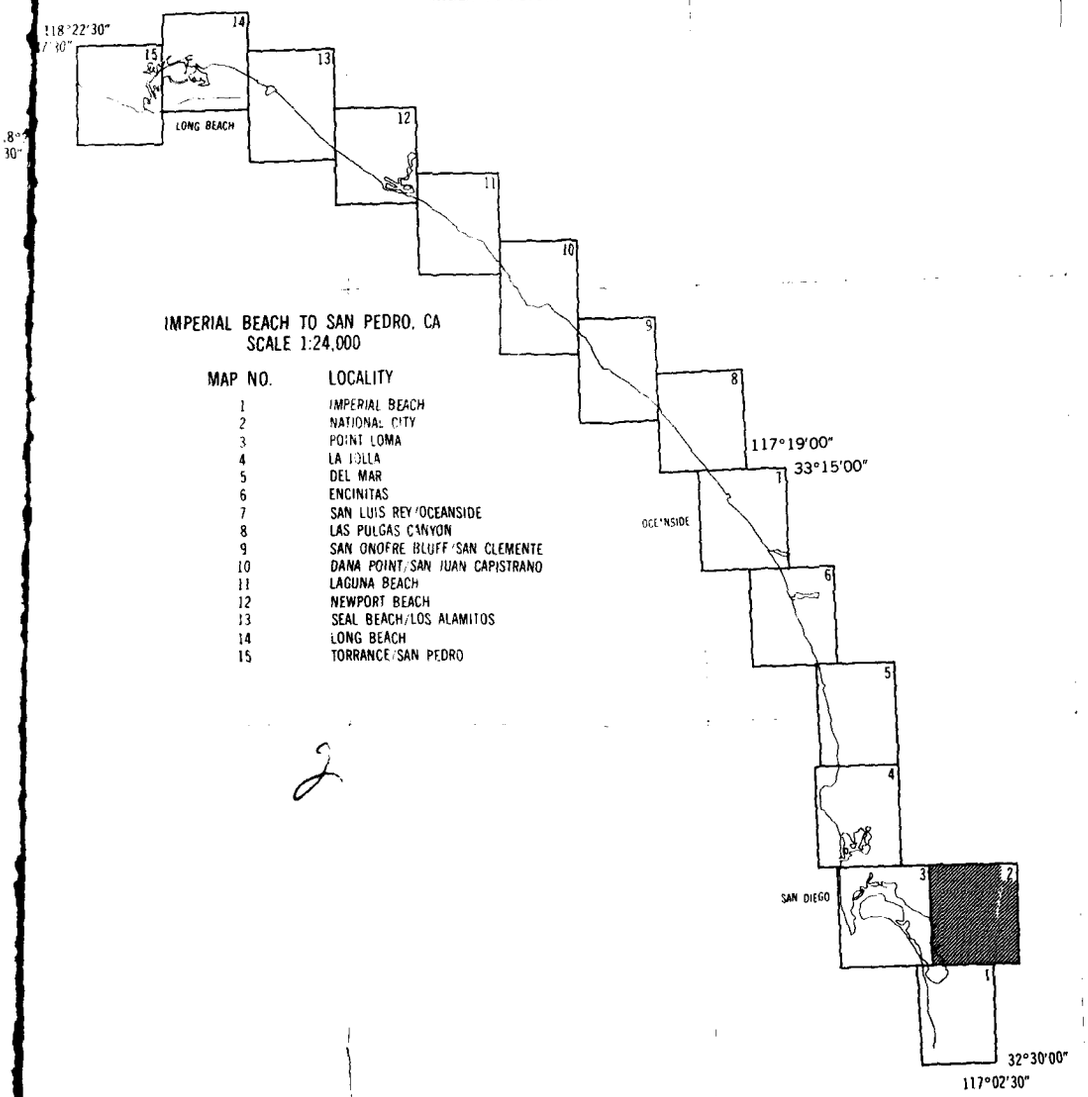

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
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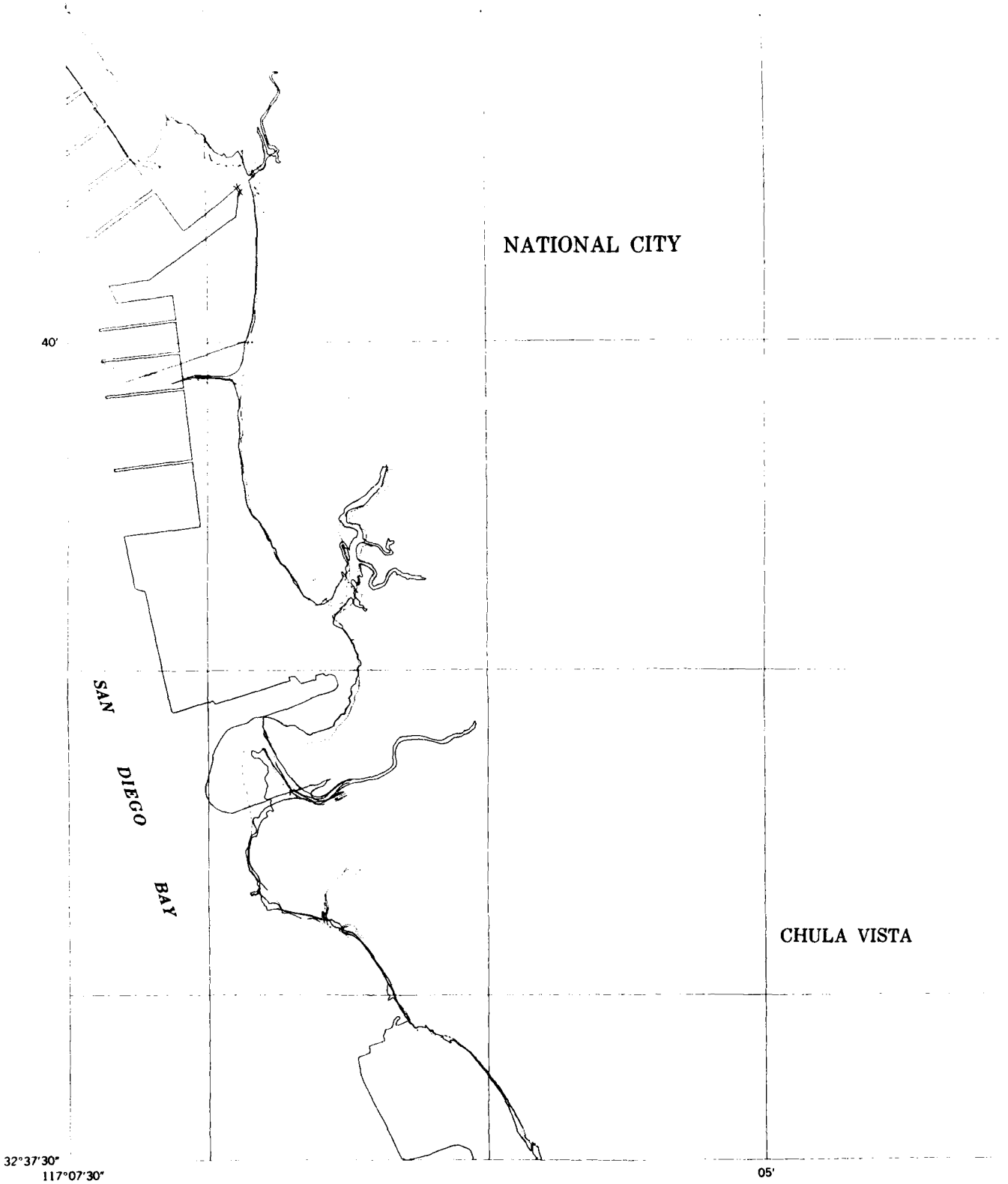
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

43'



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1000 0 1000

U.S.
NATIONAL OCE

3

32°30'00"
117°02'30"

40'

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1933 Field Survey
1916/17 Field Survey
1887 Field Survey
1852 Field Survey

02'

32°37'30"
R5852L
117°00'00"

1 24 000

1 MILE
4000 5000 6000 7000 FEET
1 KILOMETRE

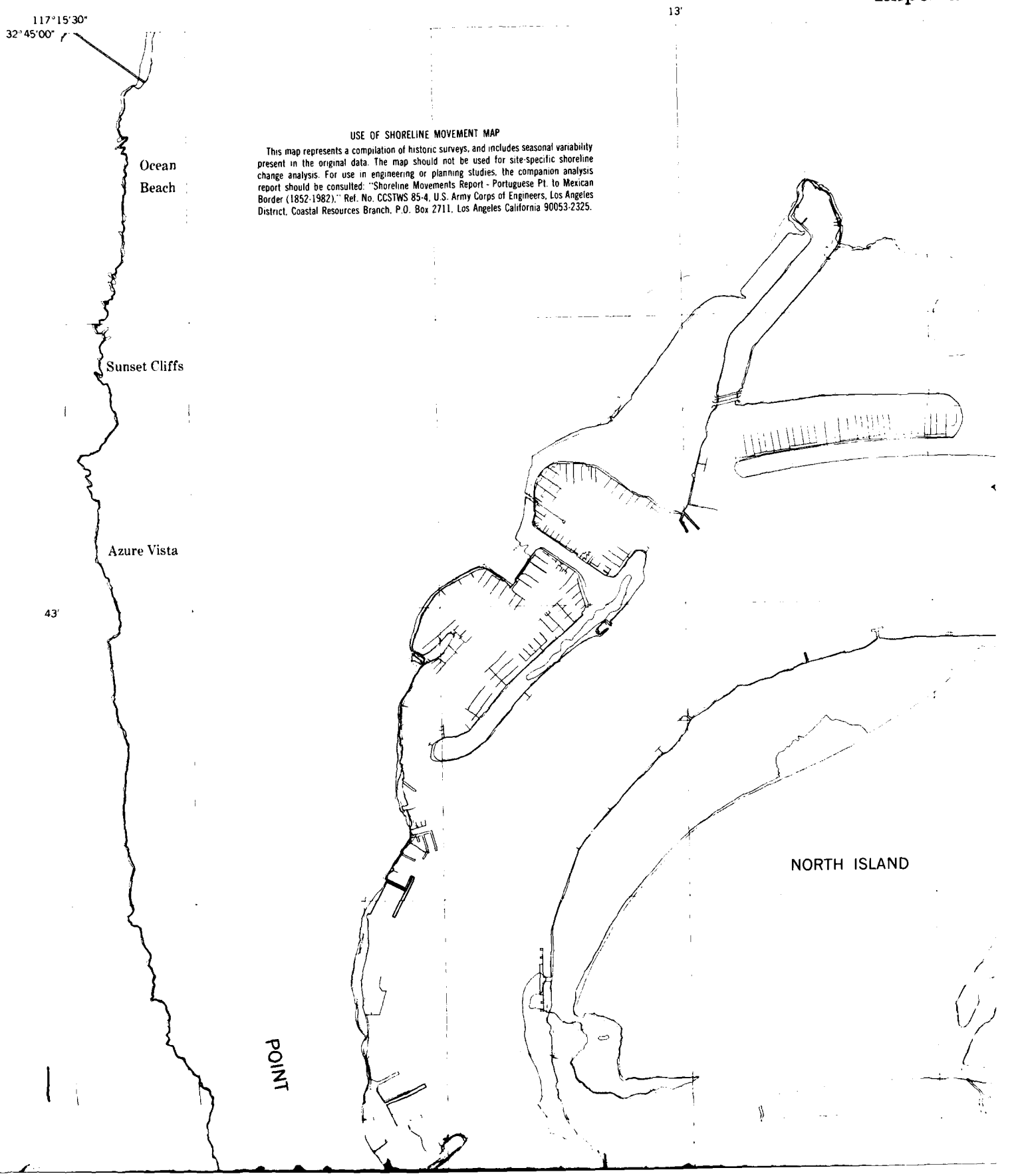
AMERICAN DATUM
PROJECTION

Washington, D.C.
NT OF COMMERCE
TMOSPHERIC ADMINISTRATION
CEAN SERVICE

4

NATIONAL CITY, CA.

NOAA/NOS - C
SHORELIN
Imperial E



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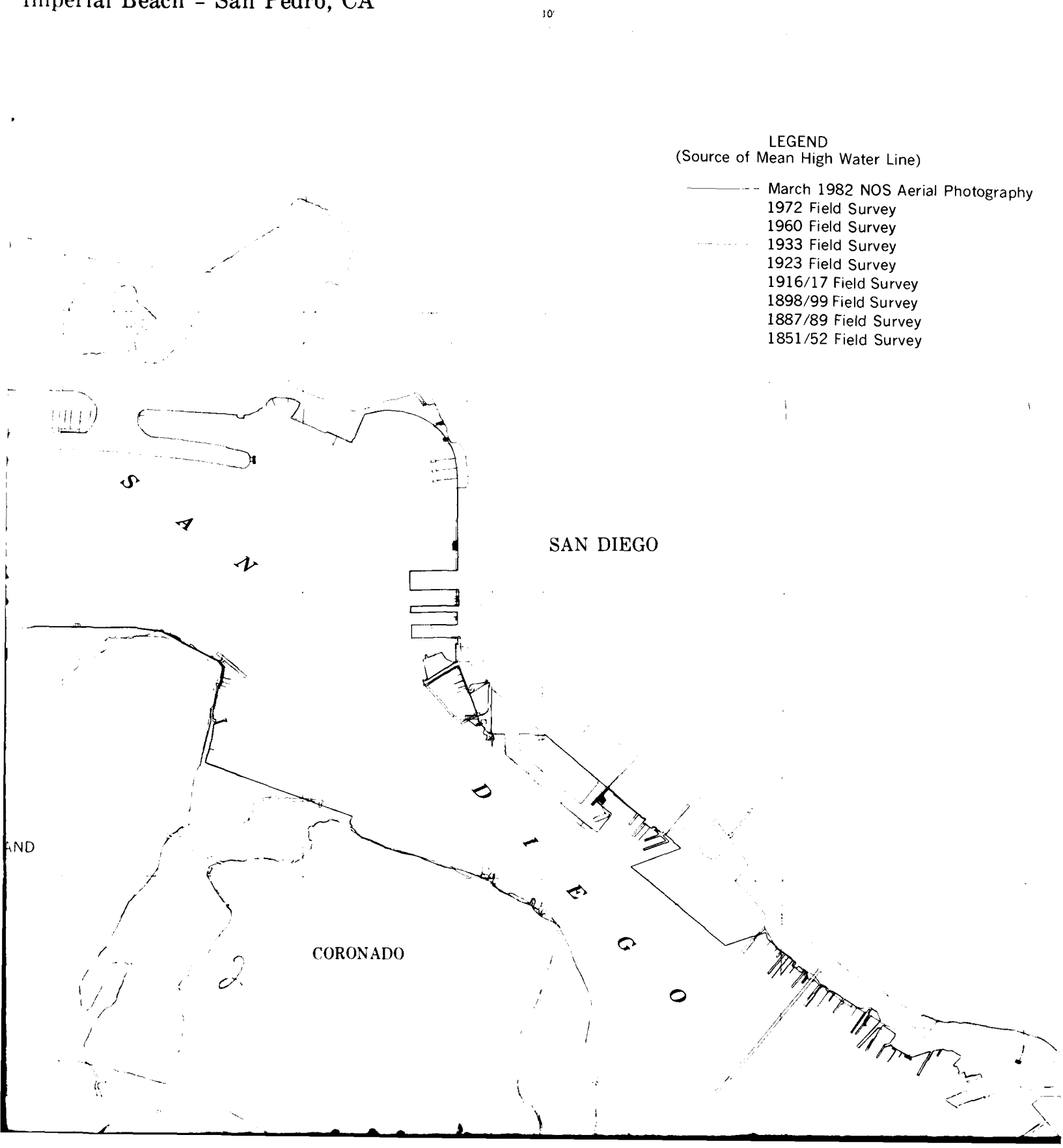
US Army Corps
of Engineers
Los Angeles District

A/NOS - COE/LAD COOPERATIVE SHORELINE MOVEMENT STUDY

Imperial Beach - San Pedro, CA

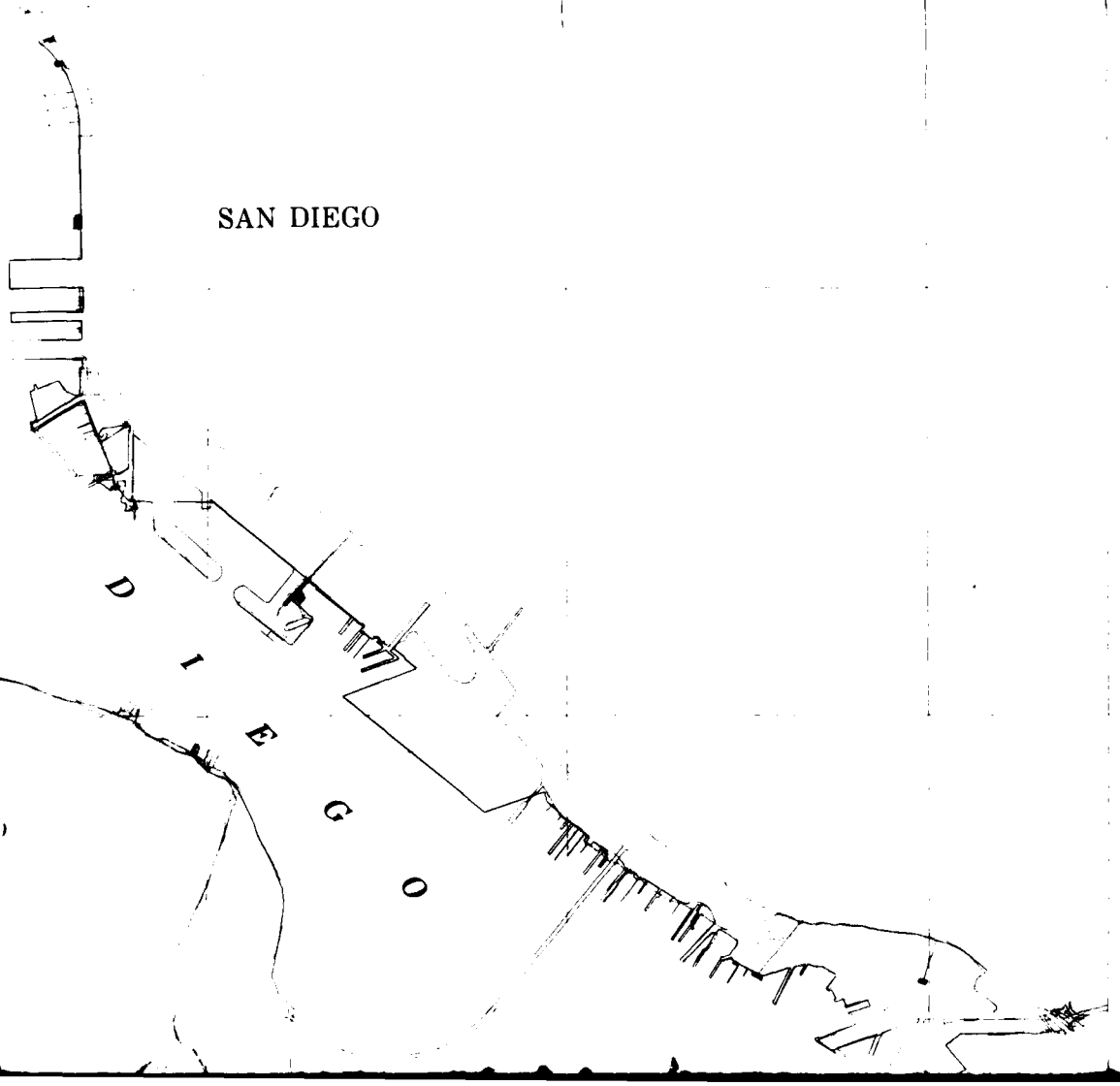


10'

117°07'30"
32°45'00"

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1933 Field Survey
1923 Field Survey
1916/17 Field Survey
1898/99 Field Survey
1887/89 Field Survey
1851/52 Field Survey



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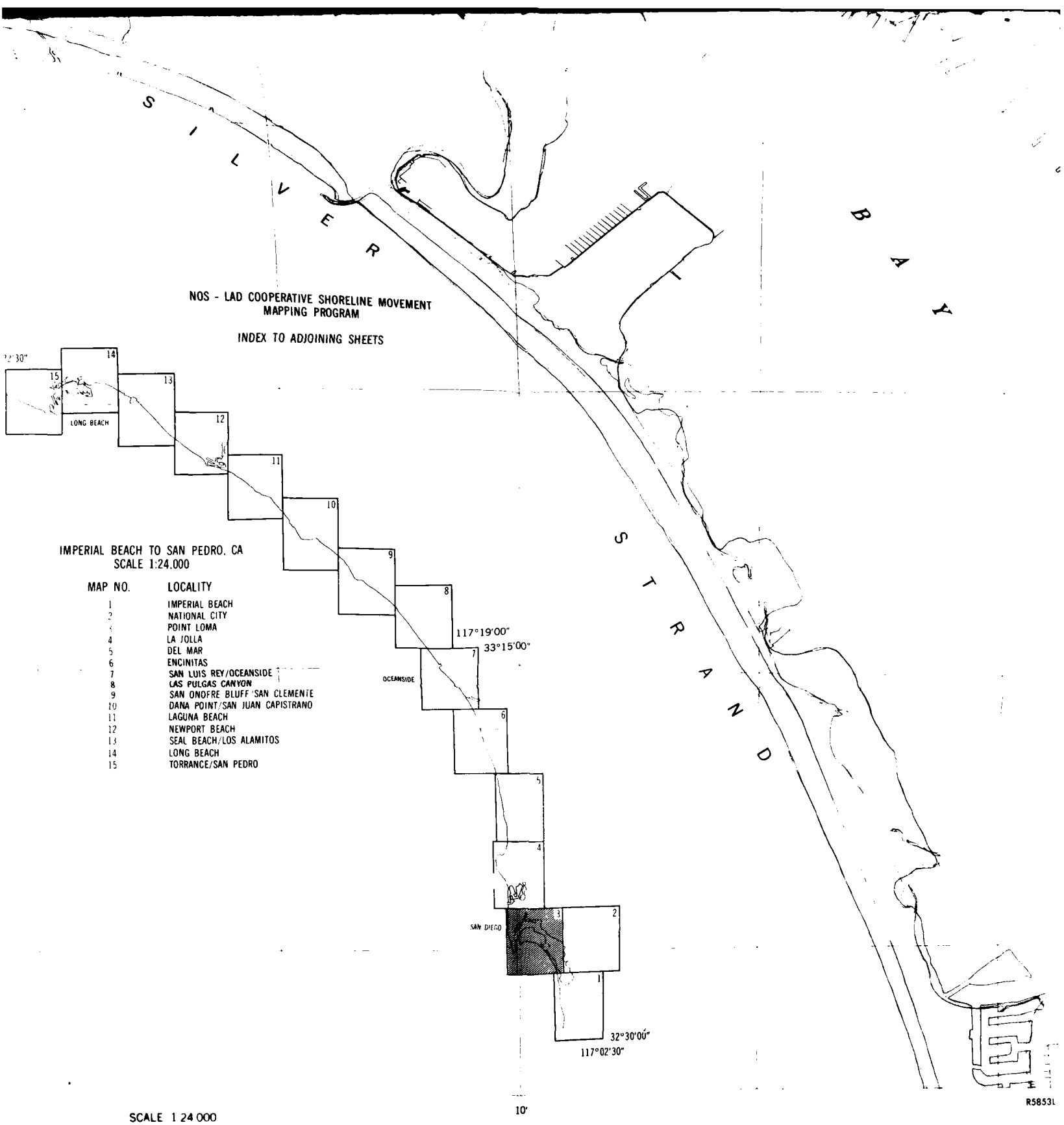
1000 0

NATIONAL

4



IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

SCALE 1 24 000

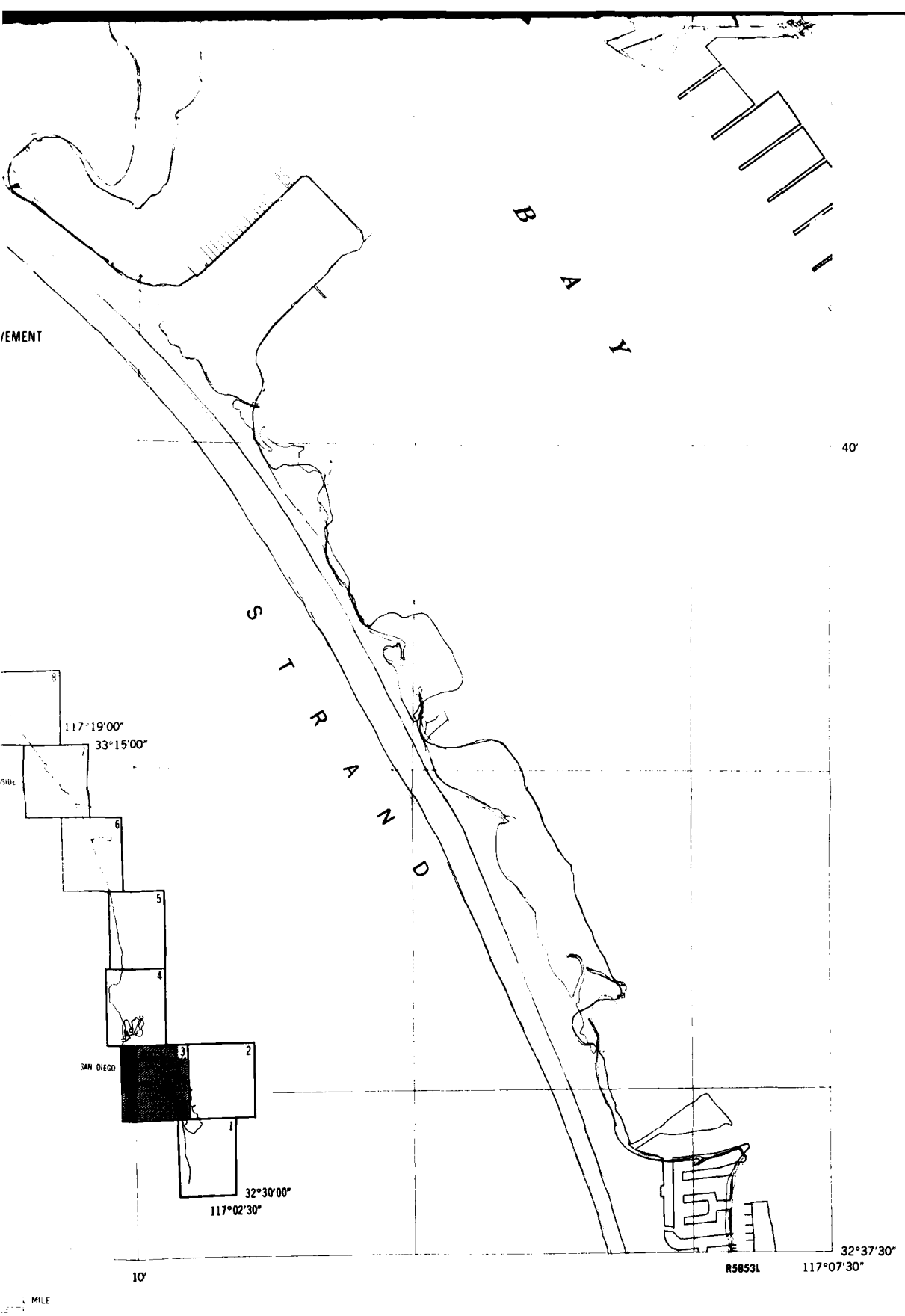
1 MILE
1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

Published at Washington, D.C.
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

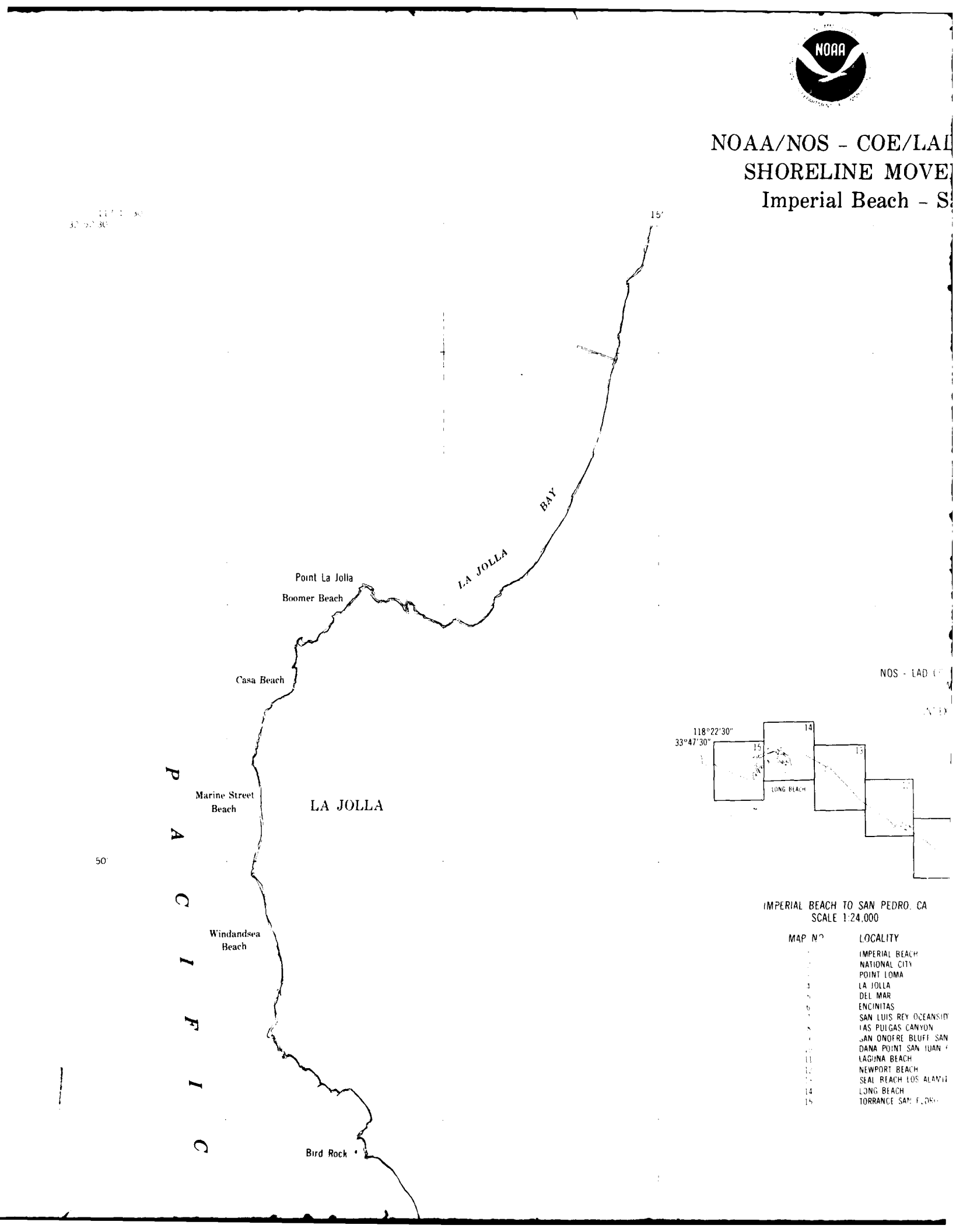
5

POINT LOM



POINT LOMA, CA.

6


NOAA/NOS - COE/LA
SHORELINE MOVE
Imperial Beach - S
15'
BAY
LA JOLLA
Point La Jolla
Boomer Beach
Casa Beach
Marine Street
Beach
LA JOLLA
50'
P A C I F I C
Windandsea
Beach
Bird Rock
NOS - LAD
118°22'30"
33°47'30"
14
15
13
LONG BEACH
IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000
MAP NO
LOCALITY
IMPERIAL BEACH
NATIONAL CITY
POINT LOMA
LA JOLLA
DEL MAR
ENCINITAS
SAN LUIS REY OCEANSID
TAS PULGAS CANYON
SAN ONOFRE BLUFF SAN
DANA POINT SAN JUAN
LAGUNA BEACH
NEWPORT BEACH
SEAL BEACH LOS ALAMI
LONG BEACH
TORRANCE SAN P

AD-A166 749 COAST OF CALIFORNIA STORM AND TIDAL WAVES STUDY 2/2
SHORELINE MOVEMENT DATA R..(U) ARMY ENGINEER DISTRICT
LOS ANGELES CA COASTAL RESOURCES BRANC..
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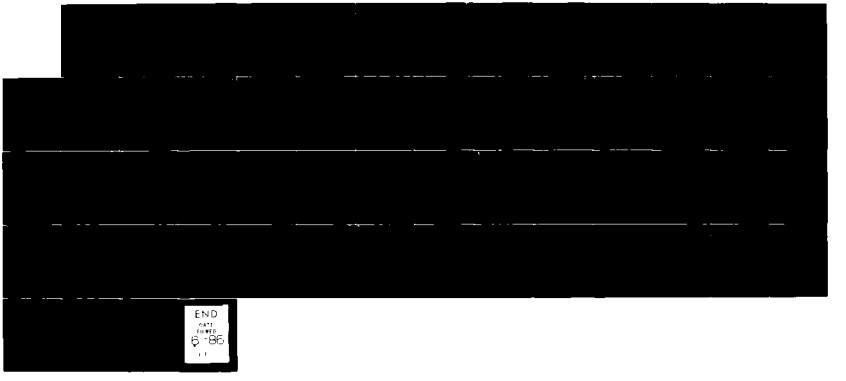

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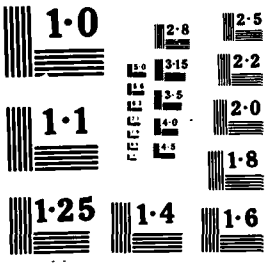
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1·4
1·6

US Army Corps of Engineers
Los Angeles District

NOS - COE/LAD COOPERATIVE SHORELINE MOVEMENT STUDY
Imperial Beach - San Pedro, CA

12

117

USE OF SHORELINE MOVEMENT MAP

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NOS - LAD COOPERATIVE SHORELINE MOVEMENT MAPPING PROGRAM

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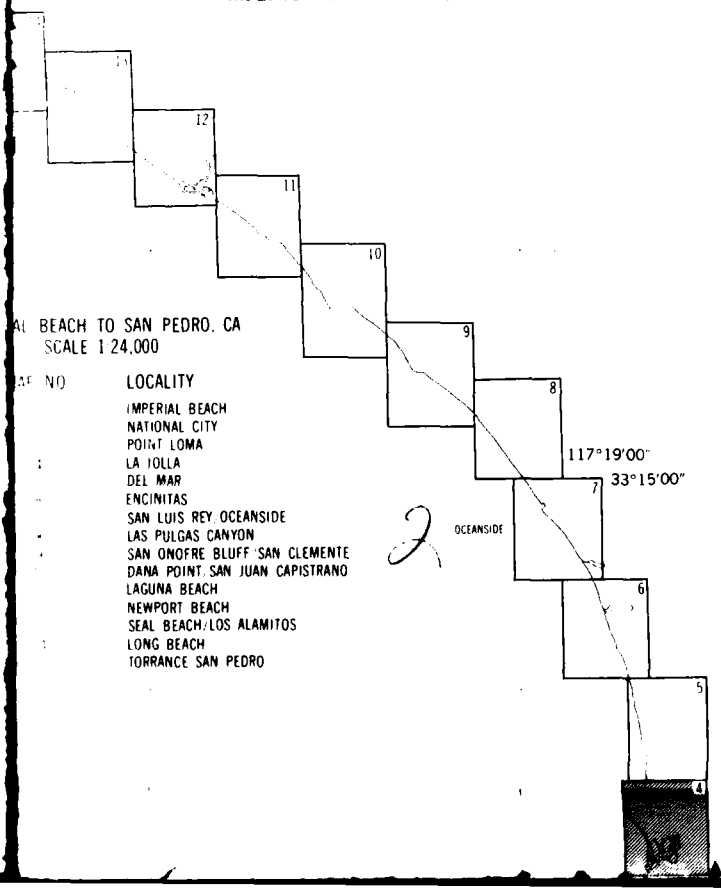

AL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

SHEET NO	LOCALITY
	IMPERIAL BEACH
	NATIONAL CITY
	POINT LOMA
	LA JOLLA
	DEL MAR
	ENCINITAS
	SAN LUIS REY/OCEANSIDE
	LAS PULGAS CANYON
	SAN ONOFRE BLUFF/SAN CLEMENTE
	DANA POINT/SAN JUAN CAPISTRANO
	LAGUNA BEACH
	NEWPORT BEACH
	SEAL BEACH/LOS ALAMITOS
	LONG BEACH
	TORRANCE/SAN PEDRO

IVE

12'

117°10'00"
32°52'30"

USE OF SHORELINE MOVEMENT MAP

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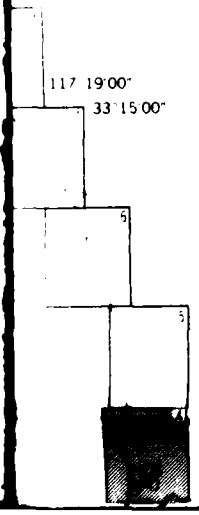
50'

117 19'00"
33°15'00"



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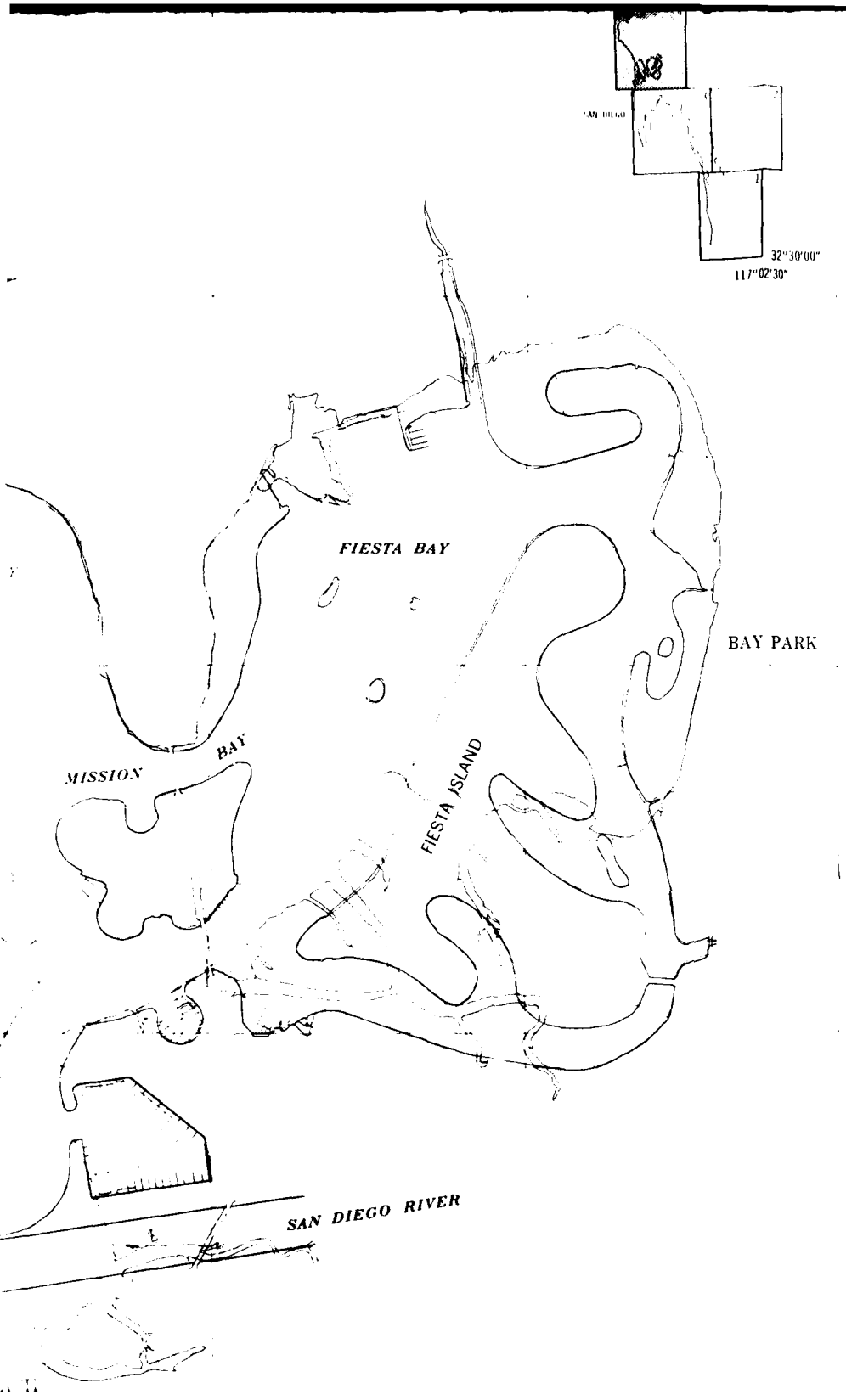
NATIO

4



LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photogra
1972 Field Survey
1960 Field Survey
1933 Field Survey
1889 Field Survey
1852 Field Survey

SCALE 1:24 000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

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NATIONAL OCEAN SERVICE

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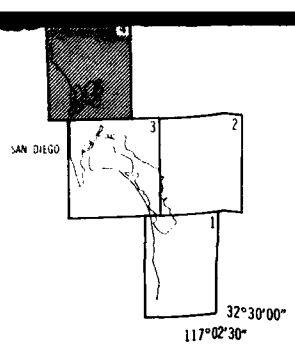
LA JOI



BAY PARK

47'

LEGEND
(Source of Mean High Water Line)

- March 1982 NOS Aerial Photography
- 1972 Field Survey
- 1960 Field Survey
- 1933 Field Survey
- 1889 Field Survey
- 1852 Field Survey

12'

32°45'00"

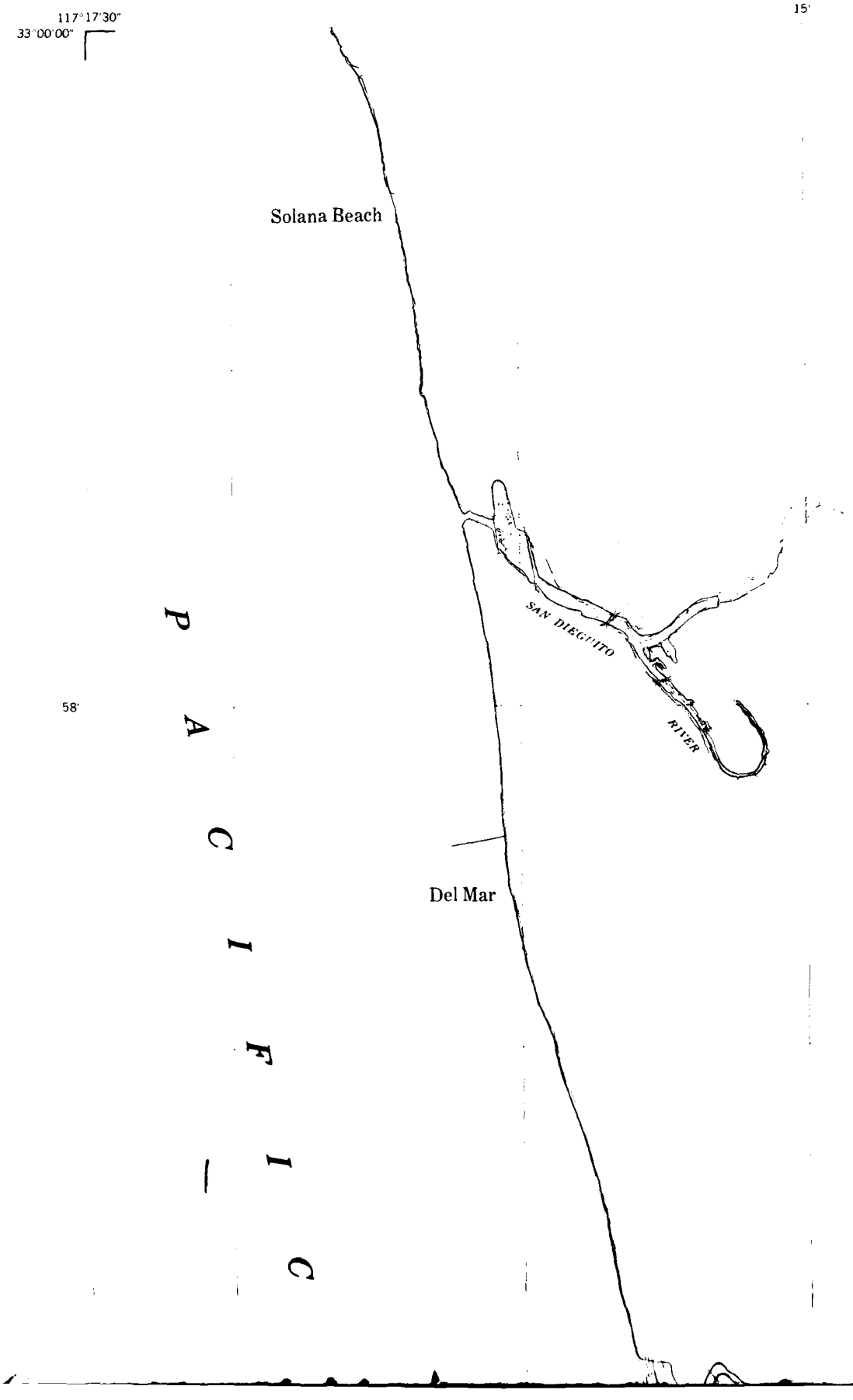
R5853R 117°10'00"

1 MILE

LA JOLLA, CA.

6

NOAA/NOS - COE/L
SHORELINE MOV
Imperial Beach -



US Army Corps
of Engineers
Los Angeles District

AD COOPERATIVE
EMENT STUDY
San Pedro, CA

12'

117°10'00"
33°00'00"

USE OF SHORELINE MOVEMENT MAP

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NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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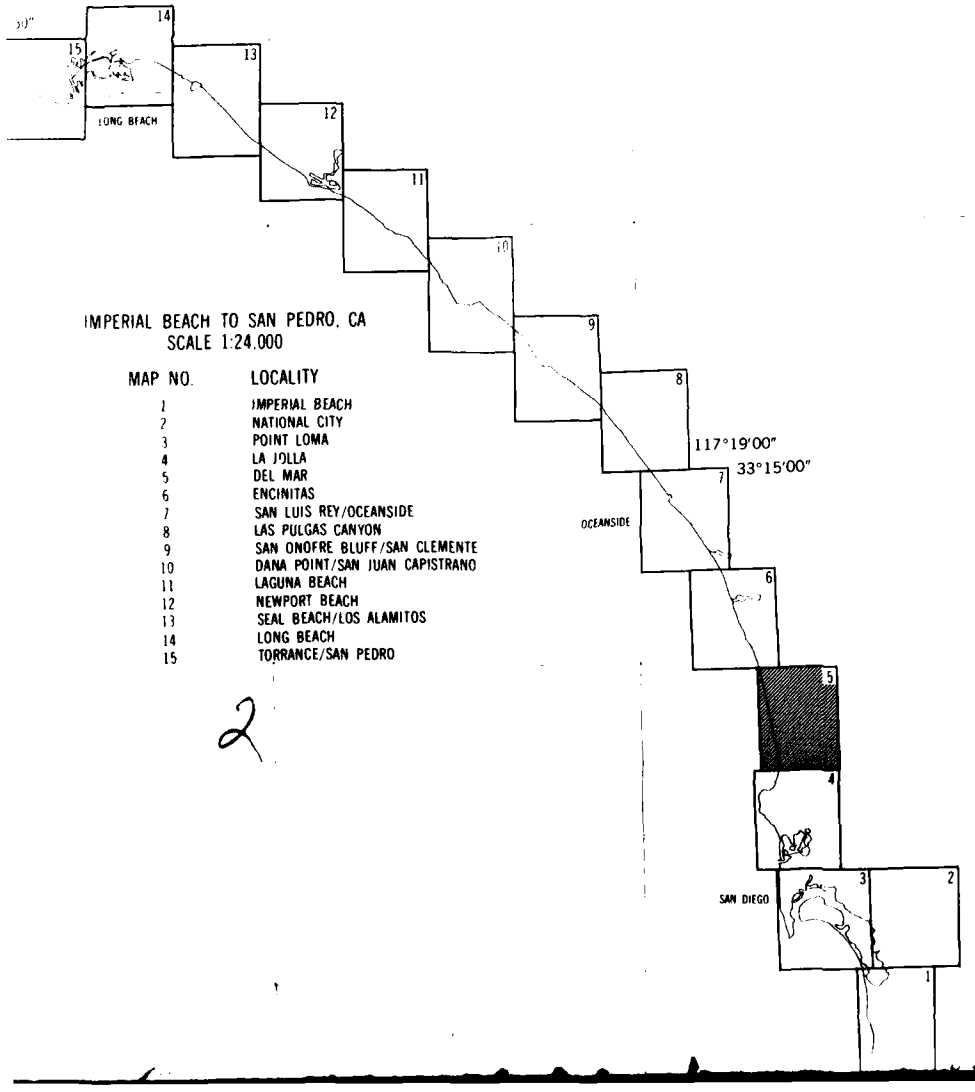
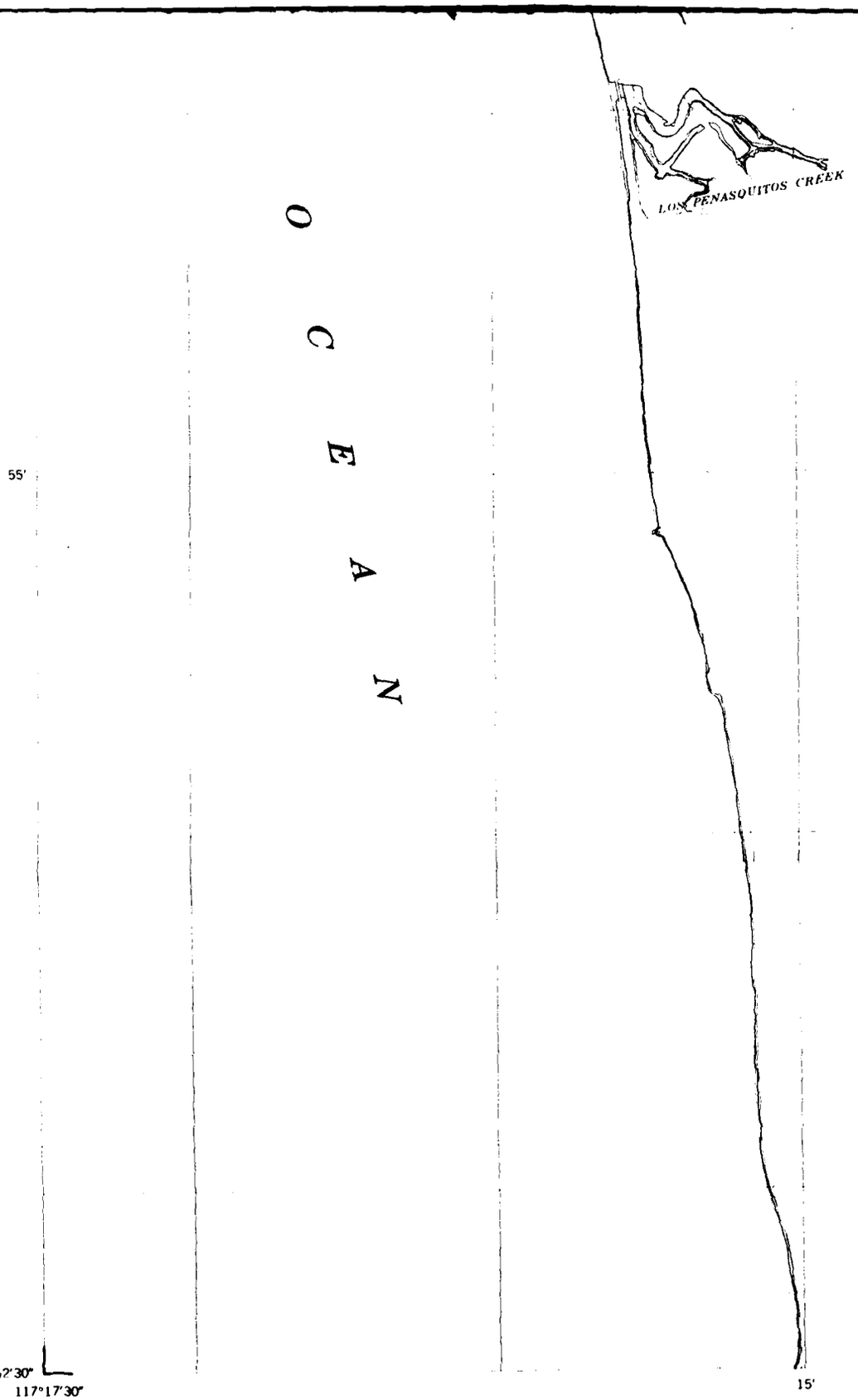


58'

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

2



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SCALE 1:

1000 0 1000 2000 3000

1927 NORTH AME
LAMBERT PR

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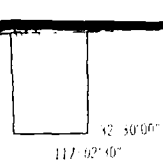
3



55'

LEGEND
(Source of Mean High Water Line)

——— March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1933/34 Field Survey
1887-89 Field Survey

12'

32°52'30"
117°10'00"

R5854L

000

1 MILE

4000 5000 6000 7000 FEET

1 KILOMETRE

CAN DATUM
ECTION

igton, D.C.
F COMMERCE
SPHERIC ADMINISTRATION
N SERVICE

DEL MAR, CA.

NOAA/NOS - COE/
SHORELINE MO
Imperial Beach

117° 22'30"
33° 07'30"

20'

05'

PACIFIC

US Army Corps
of Engineers
Los Angeles District

NOS - COE/LAD COOPERATIVE SHORELINE MOVEMENT STUDY
Imperial Beach - San Pedro, CA

USE OF SHORELINE MOVEMENT MAP

This map represents a compilation of historic surveys and includes [illegible] present in the original data. The map should not be used for [illegible] change analysis. For use in engineering or planning studies, the [illegible] report should be consulted. "Shoreline Movements Report, Portuguese Pt. to Mexican Border (1852-1982)," Ref. No. CCSTWS 85-4, U.S. Army Corps of Engineers, Los Angeles District, Coastal Resources Branch, P.O. Box 2711, Los Angeles, California 90053.

NOS - LAD COOPERATIVE SHORELINE MOVEMENT MAPPING PROGRAM

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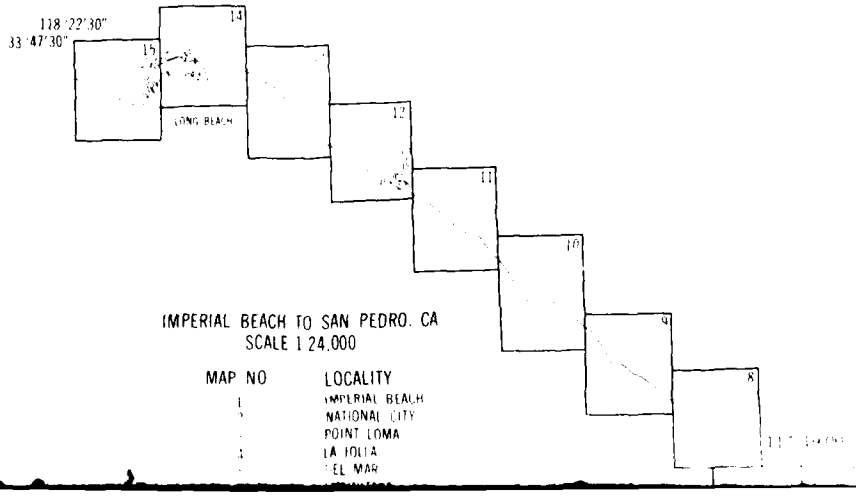

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR

11

17'

117°15'00"

33°07'30"

USE OF SHORELINE MOVEMENT MAP

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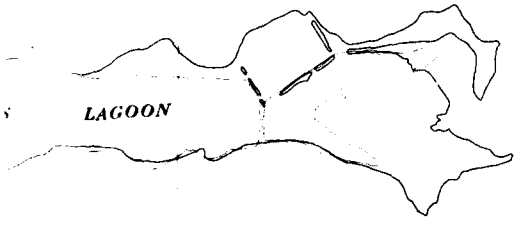

05'

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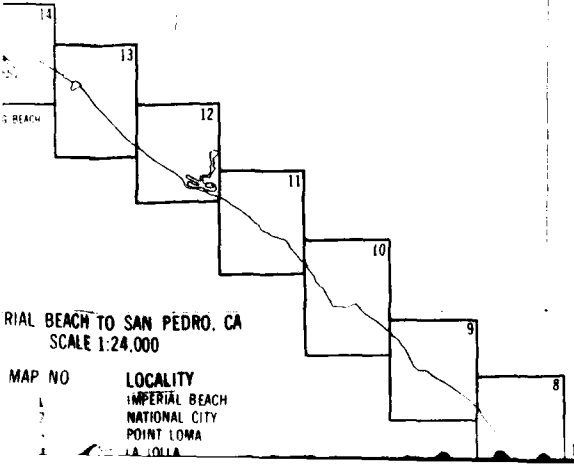

3

RIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA

117°19'00"

PACIFIC OCEAN

02'

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1934 Field Survey
1887/88 Field Survey

33°00'00"
117°22'30"

20'

1000 0 1000

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U.S.
NATIONAL OCEA
N

4

SCALE 1:24 000

0 1 MILE

0 2000 3000 4000 5000 6000 7000 FEET

0 1 KILOMETRE

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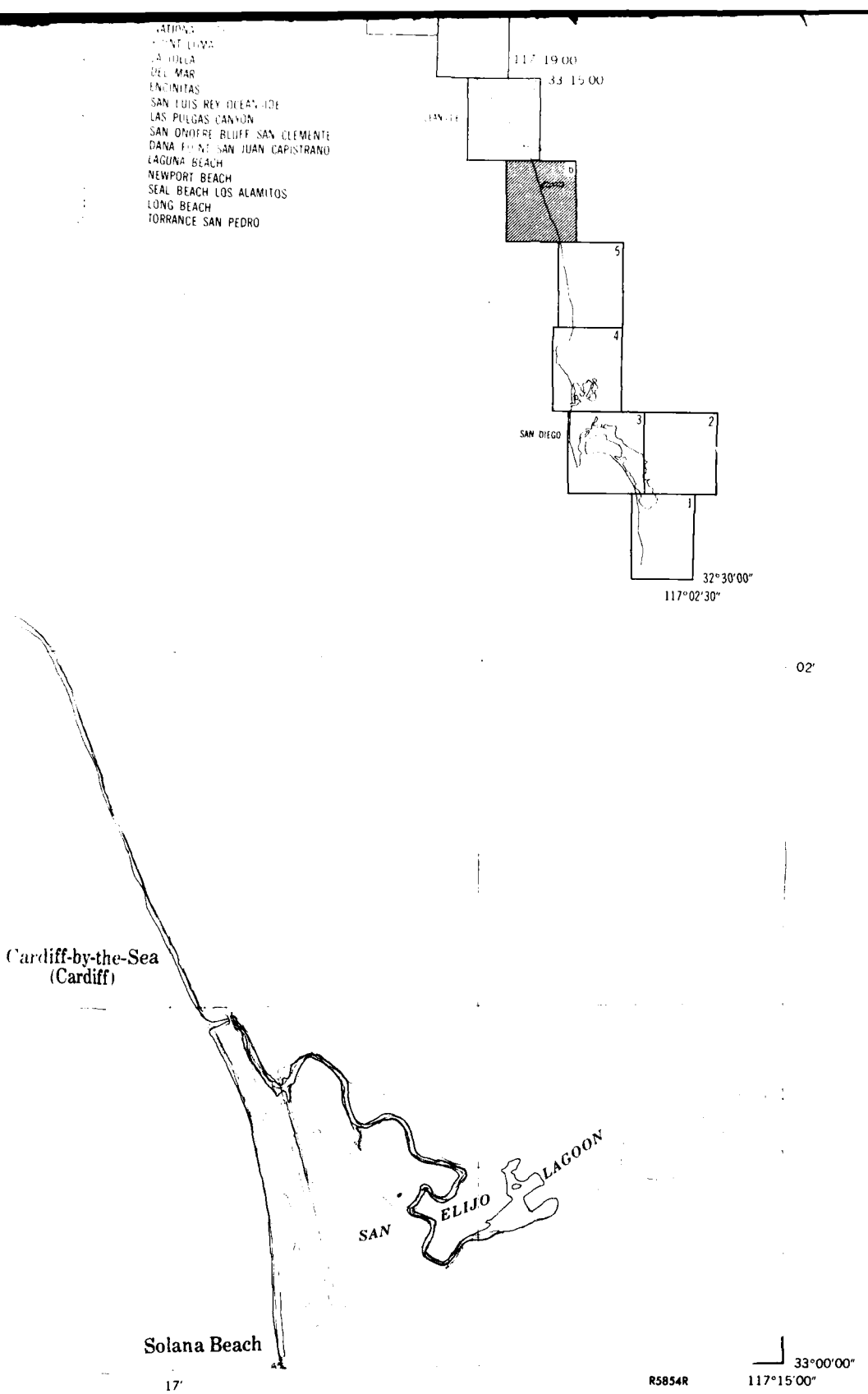
NATIONAL OCEAN SERVICE

ENCINITAS, CA.



ENCINITAS, CA.

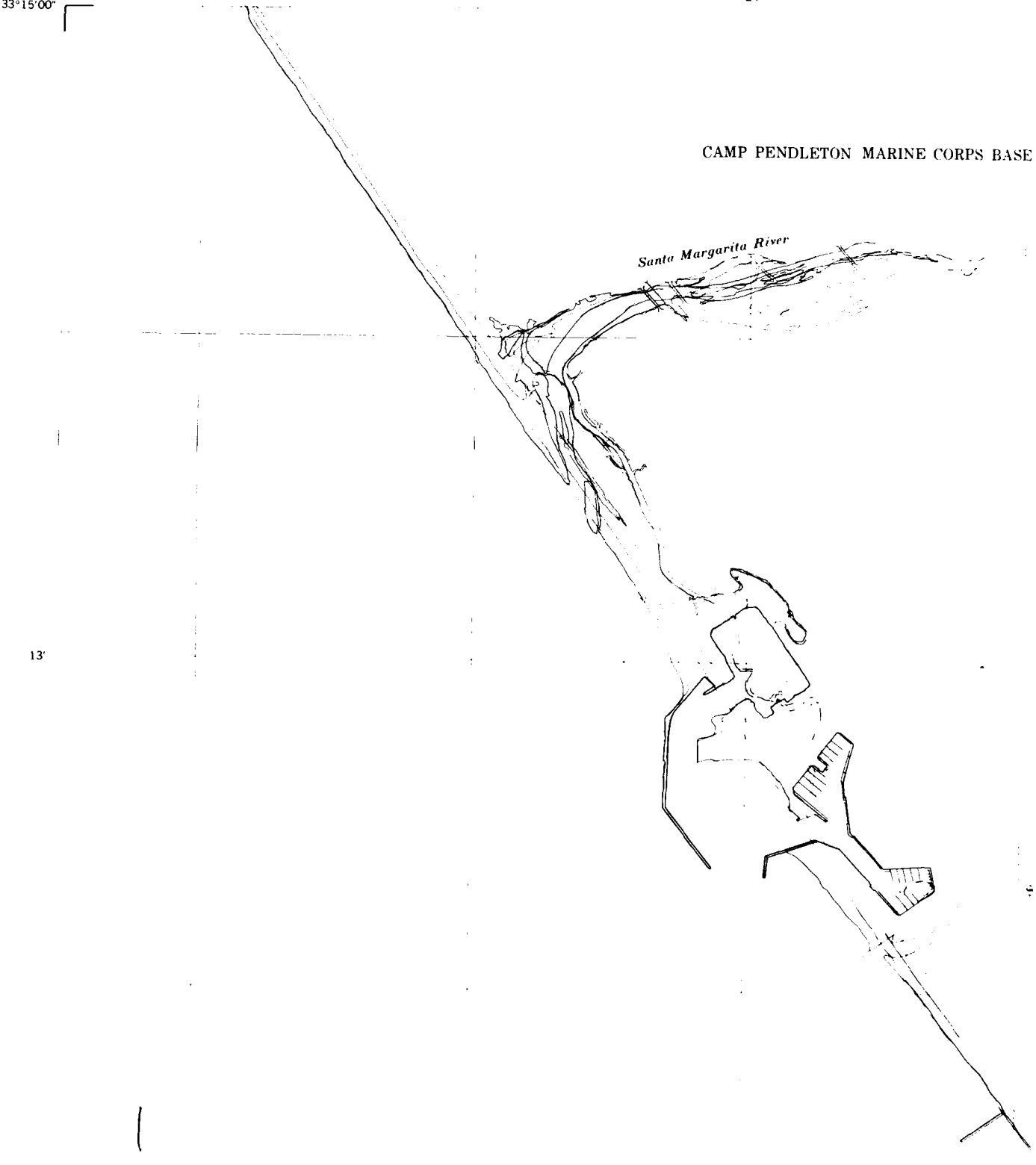
6

NOAA/NOS - CO
SHORELINE
Imperial Bea

117°26'30"
33°15'00"

24'

CAMP PENDLETON MARINE CORPS BASE



13'

US Army Corps
of Engineers
Los Angeles District

S - COE/LAD COOPERATIVE
LINE MOVEMENT STUDY
l Beach - San Pedro, CA

21'

117 19'00
33 15'00

S BASE

USE OF SHORELINE MOVEMENT MAP

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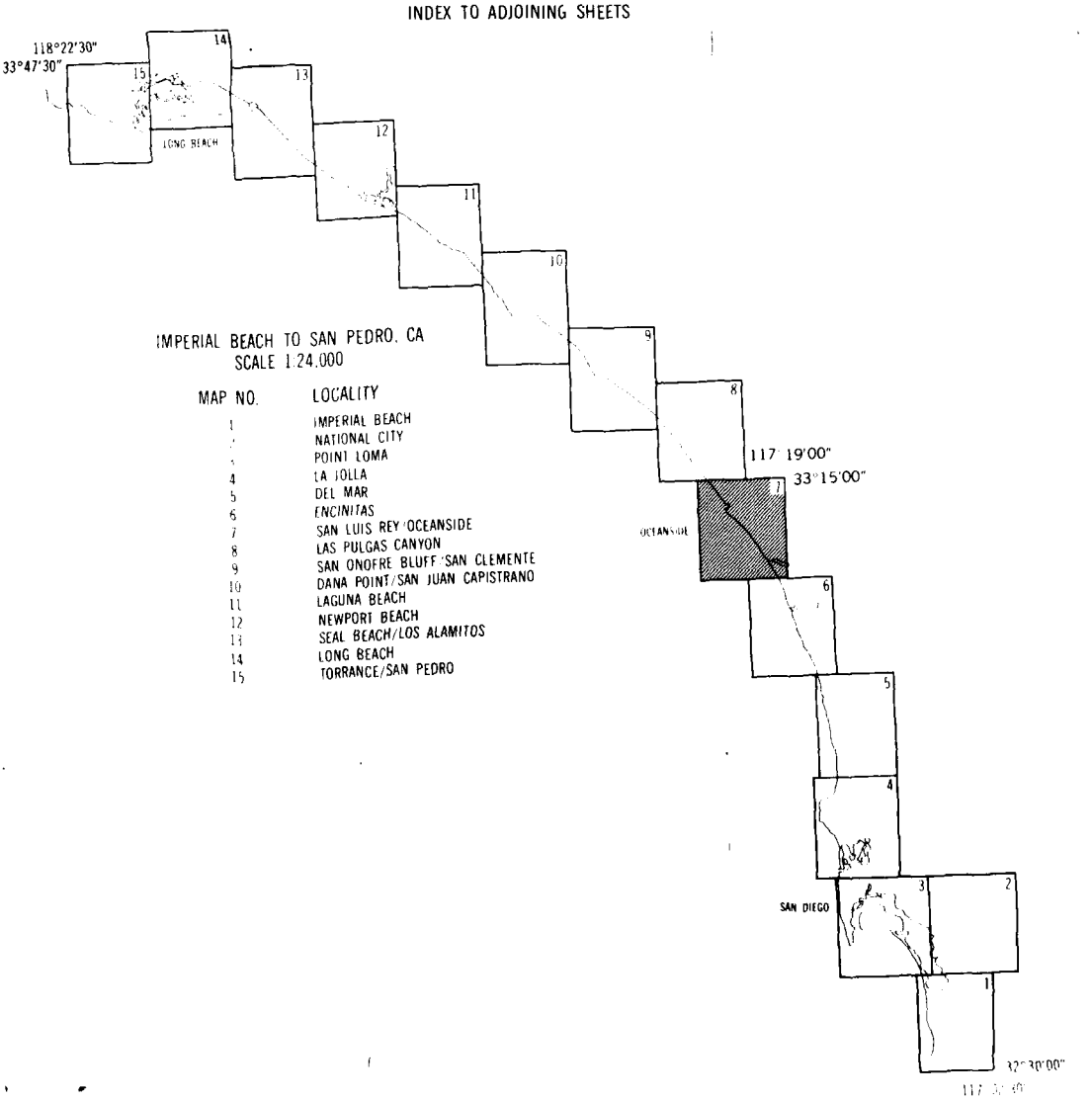

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

San Luis Rey River

OCEANSIDE

/4 V

21'

117°19'00"
33°15'00"

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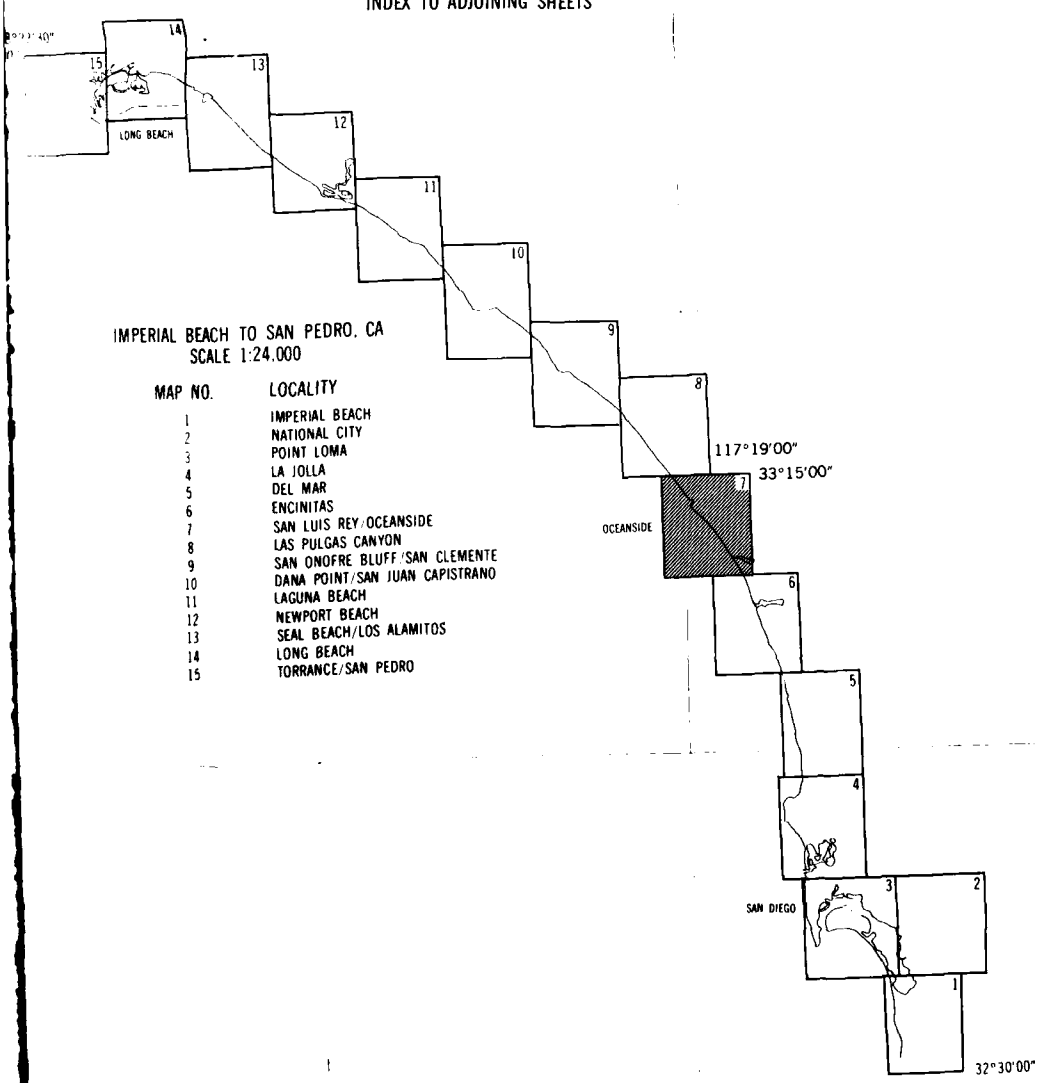
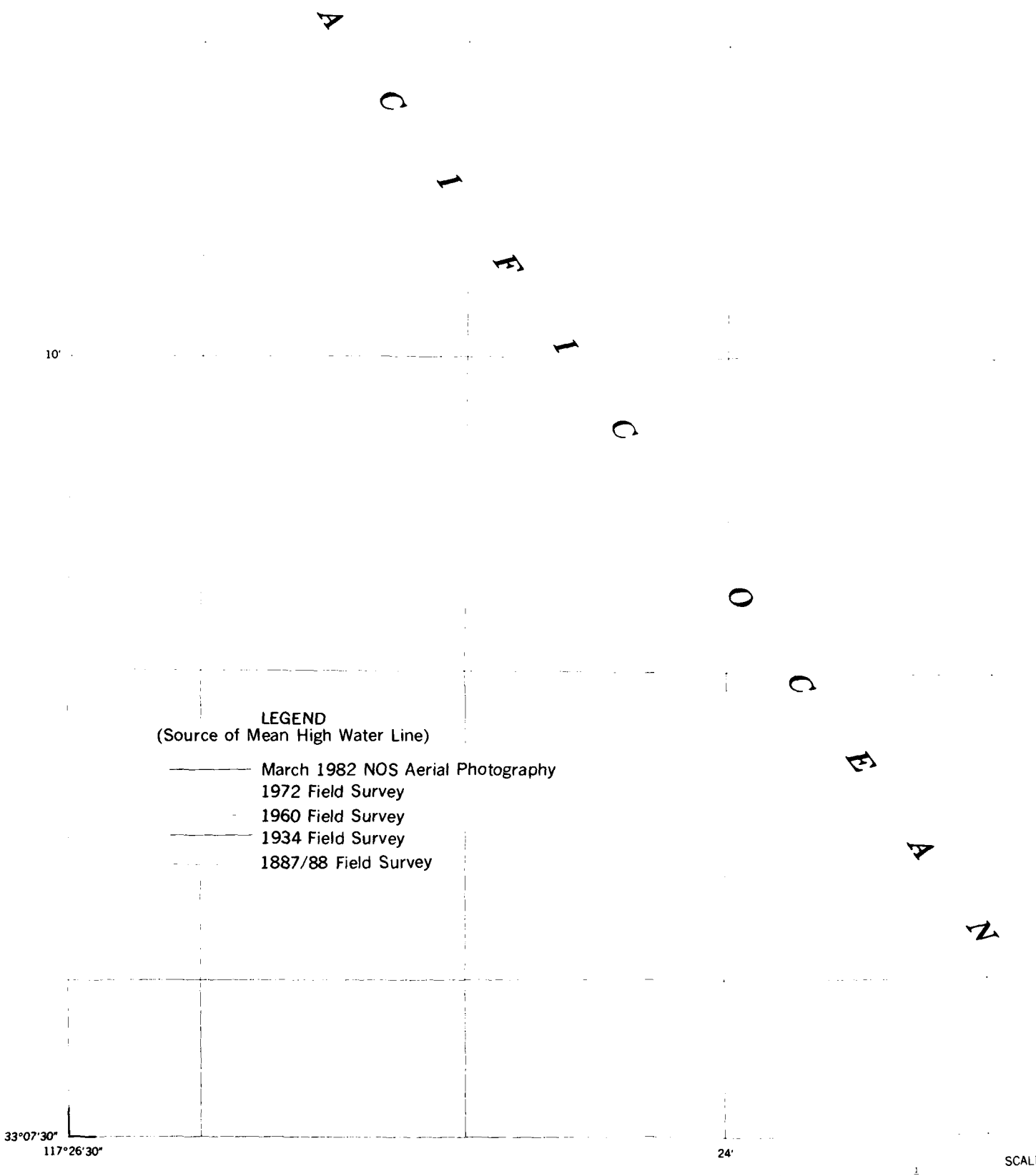


13'

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY/OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF/SAN CLEMENTE
10	DANA POINT/SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH/LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

3



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SCALE

1000 0 1000 2000

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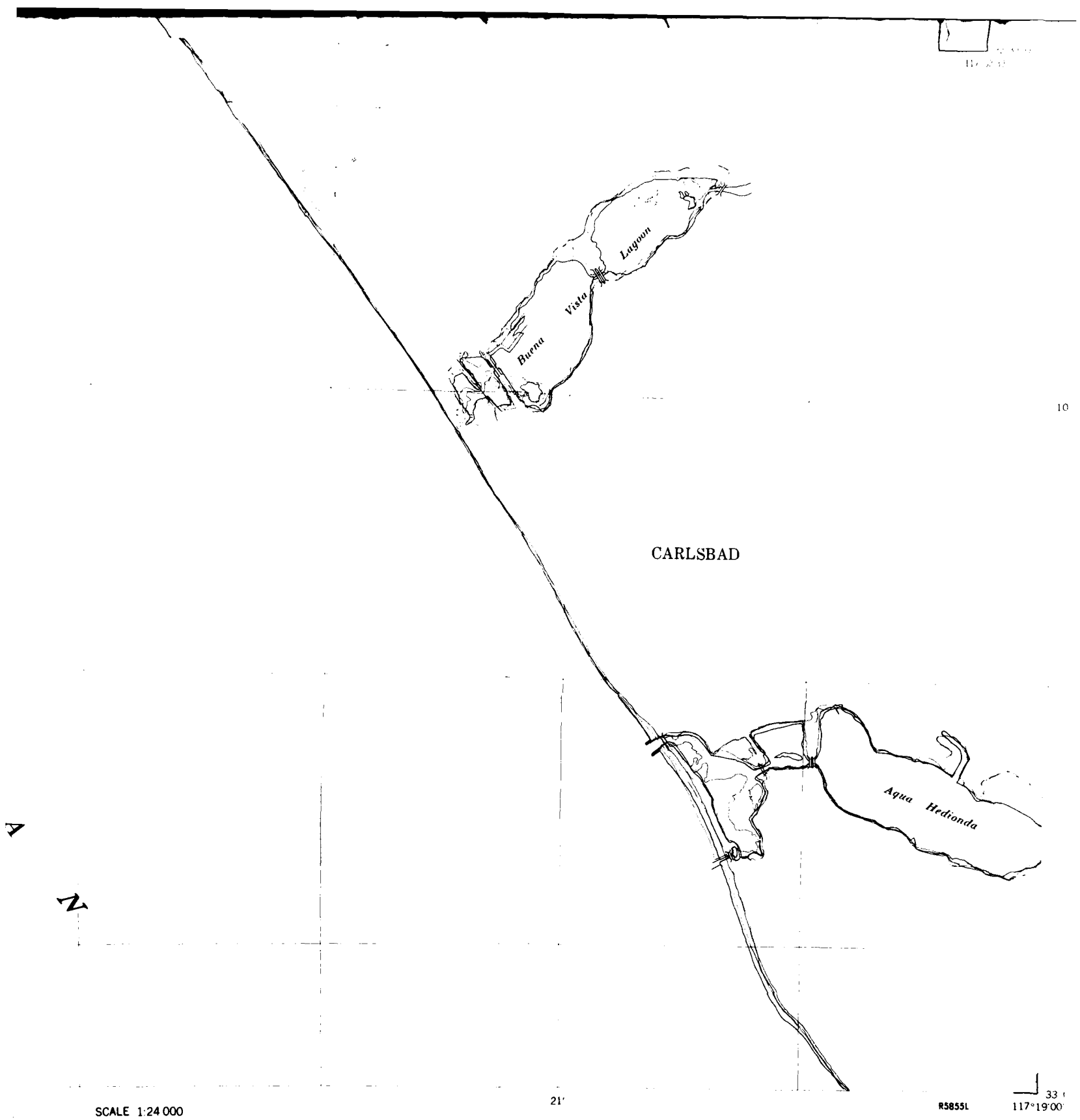
4



SCALE 1:24 000

0 1 MILE

1000 2000 3000 4000 5000 6000 7000 FEET

5 0 1 KILOMETRE

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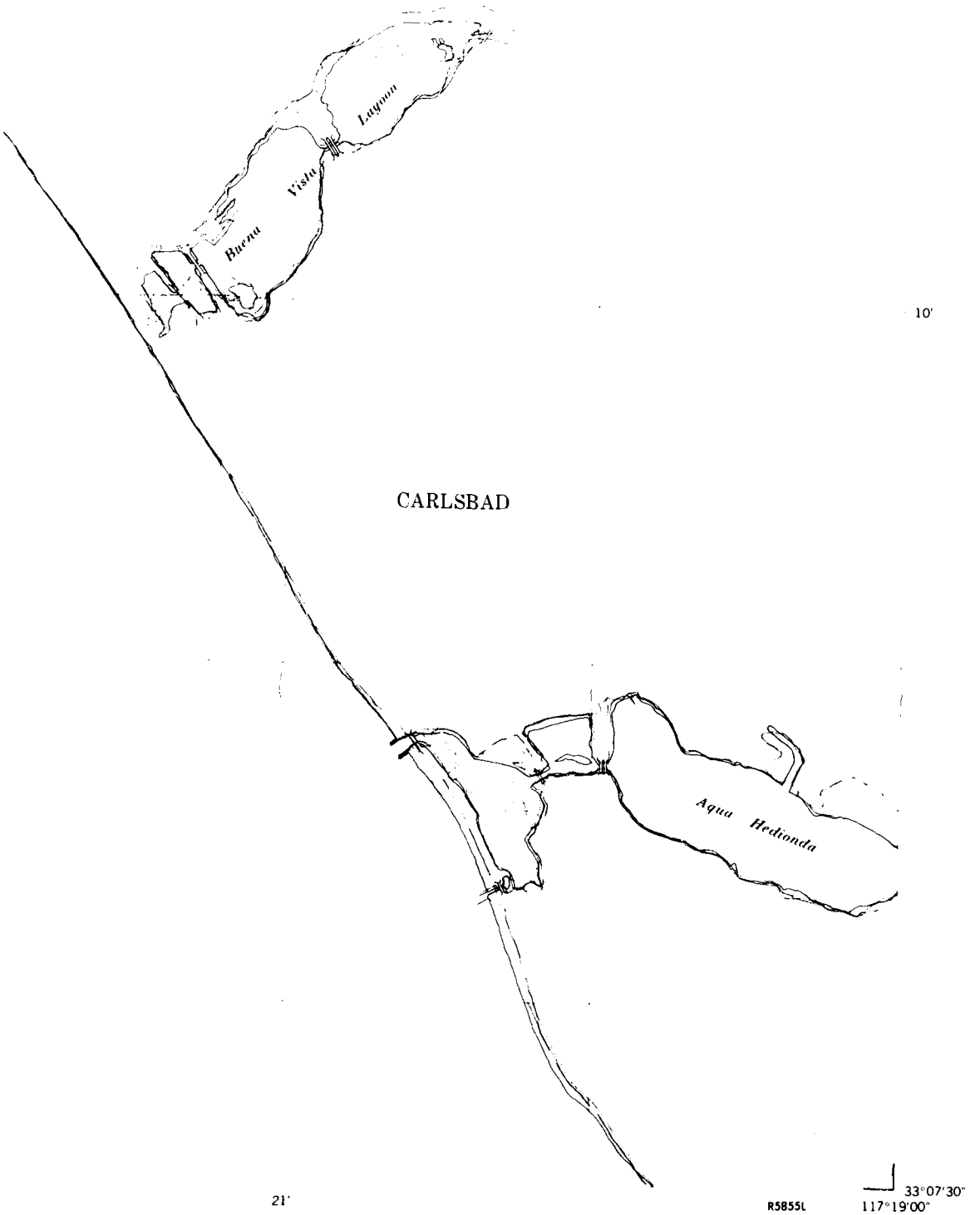
NATIONAL OCEAN SERVICE

5

SAN LUIS REY/OCEANSIDE, CA.



SAN LUIS REY/OCEANSIDE, CA.

6

NOAA/NOS - COE/LA
SHORELINE MOVE
Imperial Beach - S

117°30'00"
33°22'30"

28'

USE OF SHORELINE MOVEMENT MAP

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CANYON

HORNO

20'

C A M P P E N D L

M A R I N E C O R P

US Army Corps
of Engineers
Los Angeles District

- COE/LAD COOPERATIVE
INE MOVEMENT STUDY
l Beach - San Pedro, CA

25'

117°22'30"
33 22' 30

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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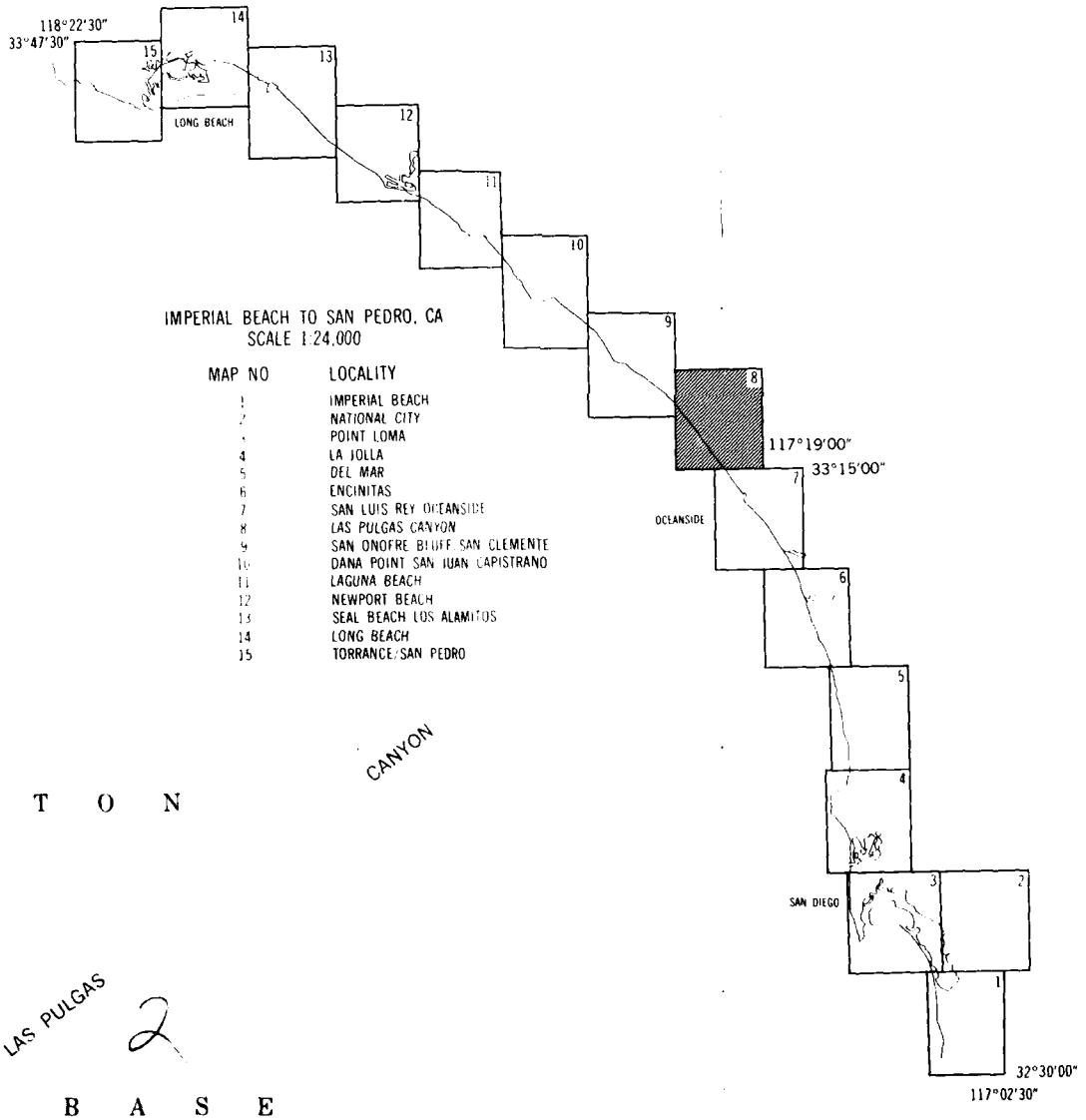

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF SAN CLEMENTE
10	DANA POINT SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH LOS ALAMITOS
14	LONG BEACH
15	TORRANCE/SAN PEDRO

CANYON

N D L E T O N

LAS PULGAS 2

O R P S B A S E

117°22'30"
33°22'30"

LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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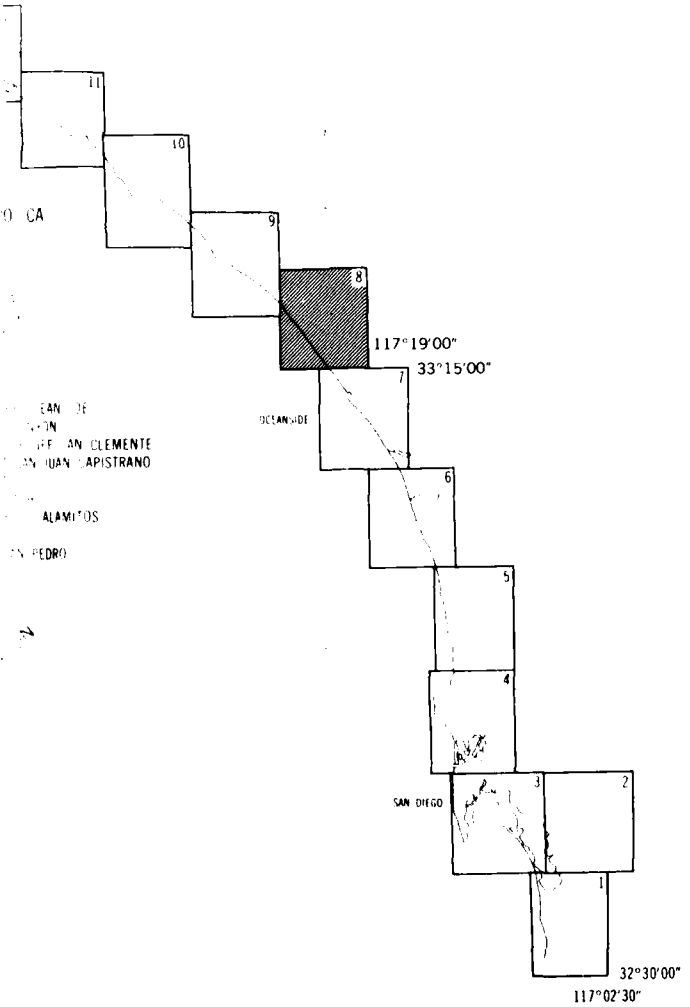
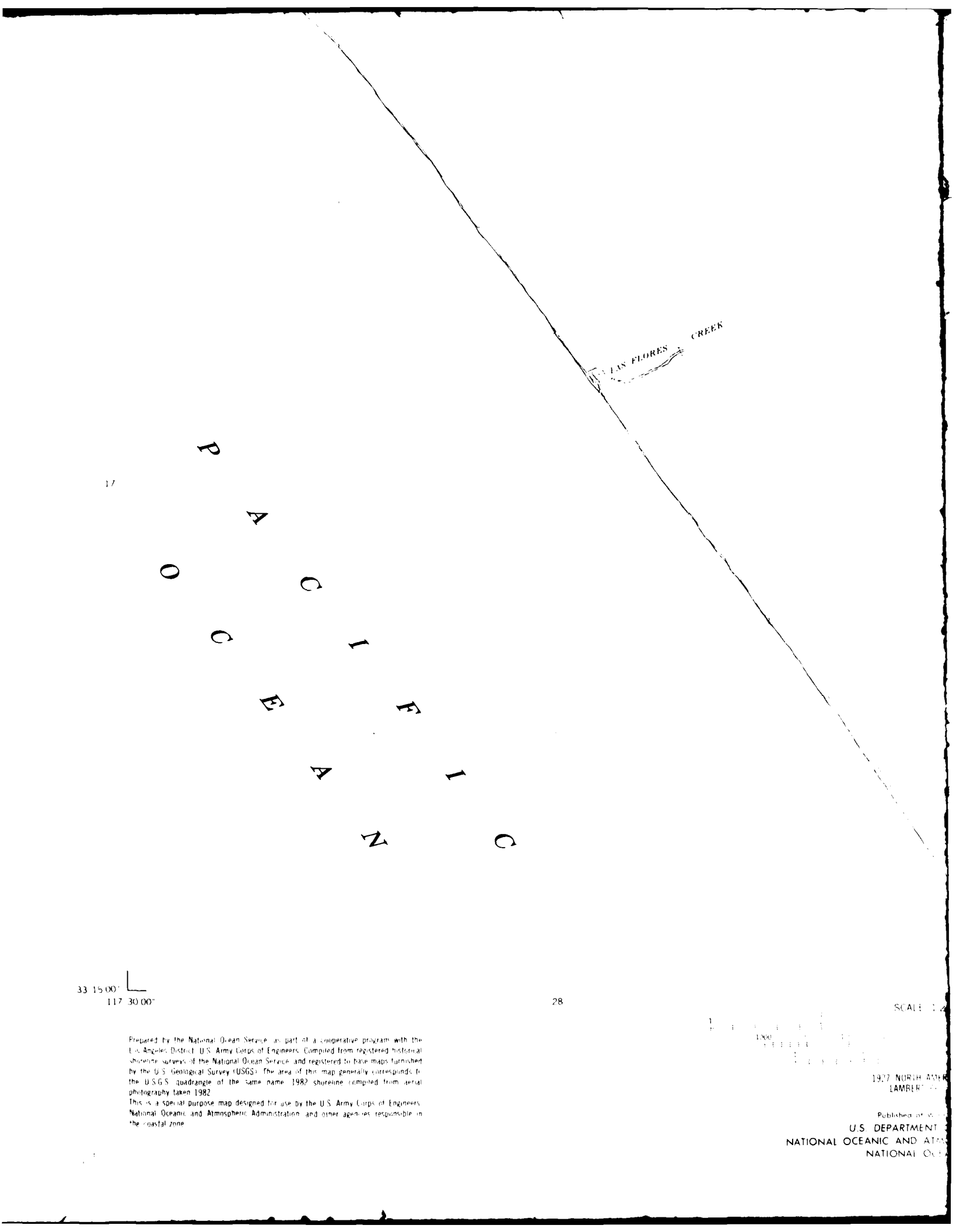


20'

3



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SCALE 1:2

1000

1927 NORTH AMER
LAMBERT

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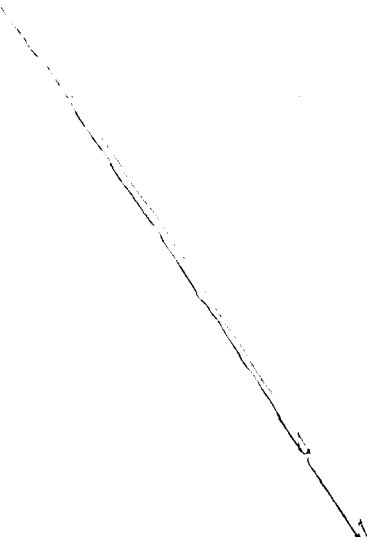
ALISO

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1934 Field Survey
1887-89 Field Survey



R5B55R

SCALE 1:24 000

1 MILE

1 KILOMETRE

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LAMBERT PROJECTION

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U.S. DEPARTMENT OF COMMERCE
)NAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

LAS PULGAS CANYON, CA.

CANYON

17'

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1934 Field Survey
1887-89 Field Survey

25'

R5855R

33°15'00"
117°22'30"

LAS PULGAS CANYON, CA.

6

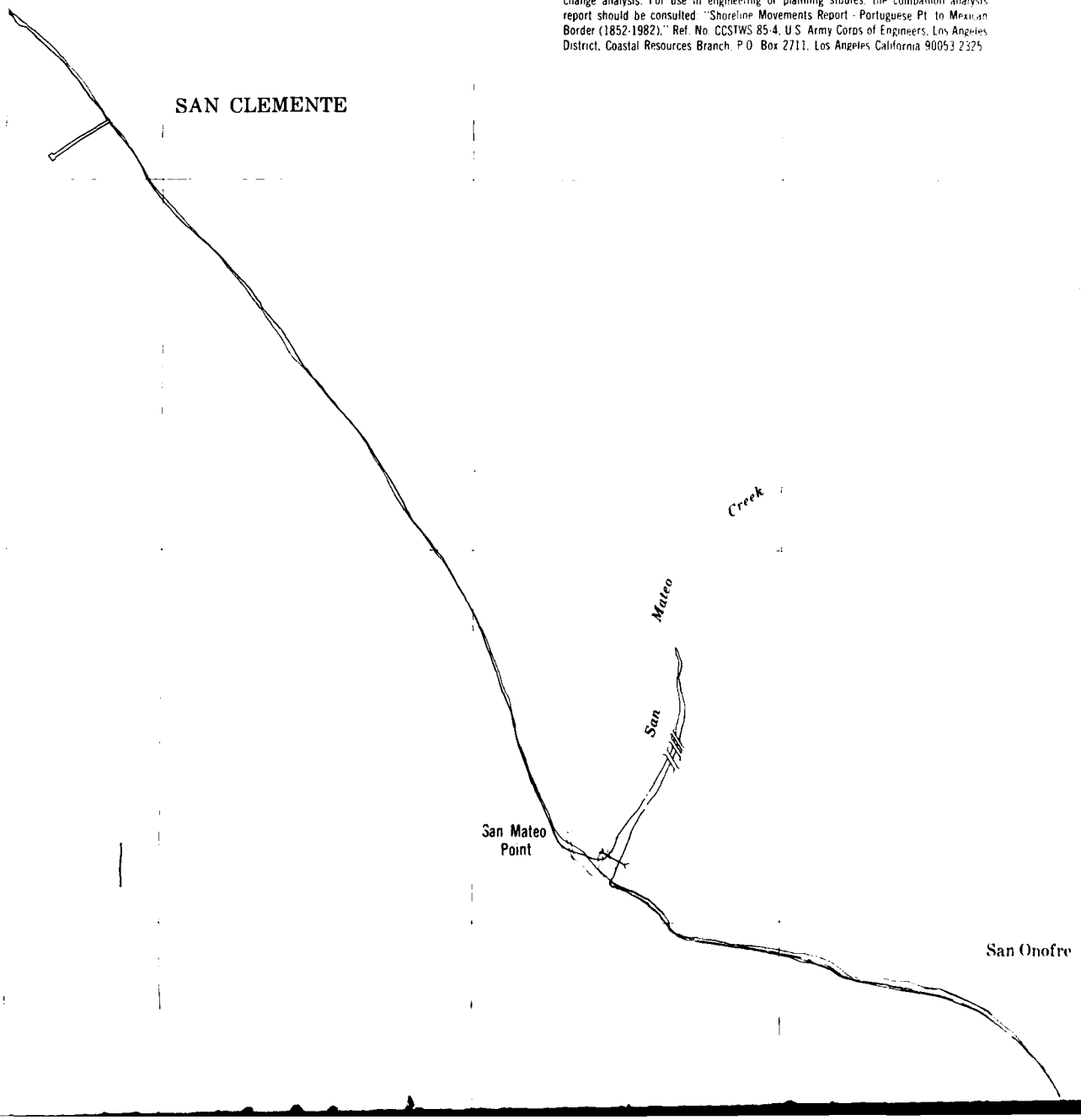
NOAA/NOS - COE/
SHORELINE MC
Imperial Beach

117°37'30"
33°26'30"

35'

USE OF SHORELINE MOVEMENT MAP

This map represents a compilation of historic surveys, and includes seasonal variability present in the original data. The map should not be used for site-specific shoreline change analysis. For use in engineering or planning studies, the companion analysis report should be consulted: "Shoreline Movements Report - Portuguese Pt. to Mexican Border (1852-1982)," Ref. No. CCSTWS 85-4, U.S. Army Corps of Engineers, Los Angeles District, Coastal Resources Branch, P.O. Box 2711, Los Angeles California 90053-2325.



US Army Corps of Engineers
Los Angeles District

NOS - COE/LAD COOPERATIVE
ORELINE MOVEMENT STUDY
perial Beach - San Pedro, CA

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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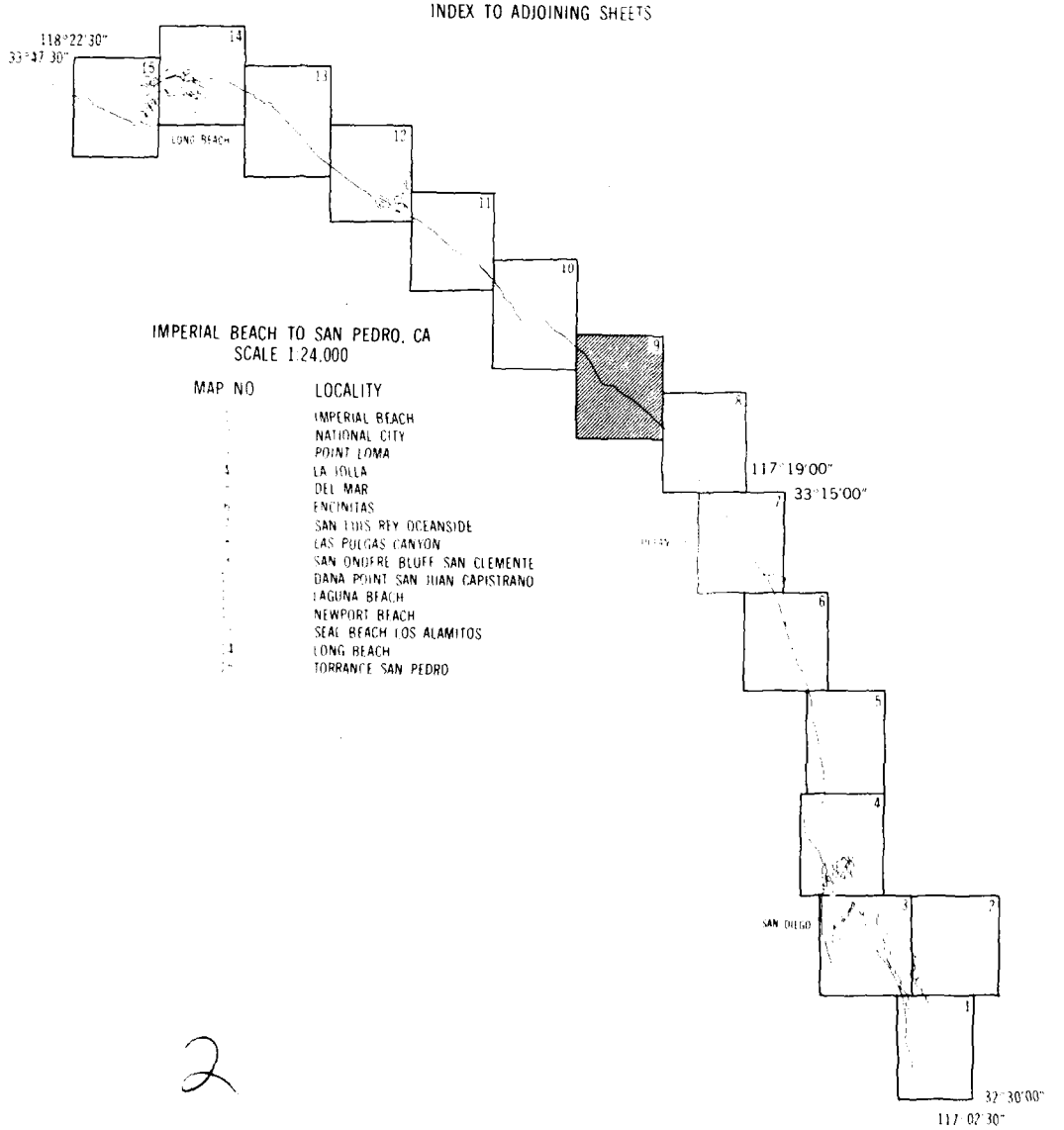


IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

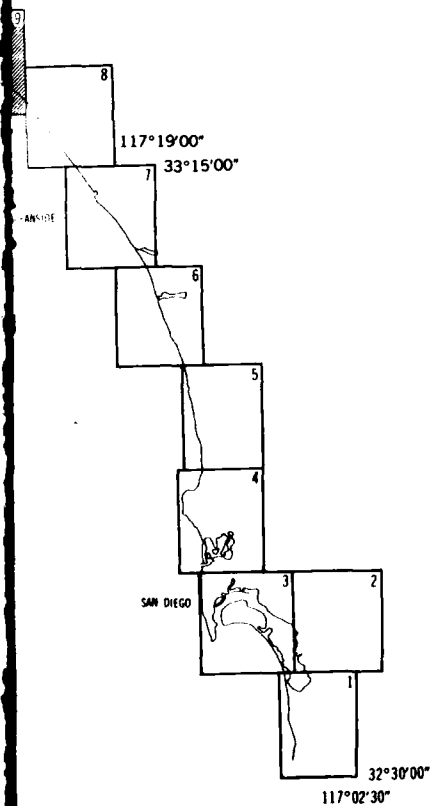
MAP NO	LOCALITY
	IMPERIAL BEACH
	NATIONAL CITY
	POINT LOMA
4	LA JOLLA
	DEL MAR
	ENCINITAS
	SAN LUIS REY OCEANSIDE
	LAS PULGAS CANYON
	SAN ONOFRE BLUFF SAN CLEMENTE
	DANA POINT SAN JUAN CAPISTRANO
	LAGUNA BEACH
	NEWPORT BEACH
	SEAL BEACH LOS ALAMITOS
1	LONG BEACH
	TORRANCE SAN PEDRO

2

32'

117°30'00"
33°26'30"

OVEMENT



24'

3

P A C I F I C

21'

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1972 Field Survey
1960 Field Survey
1934 Field Survey
1889 Field Survey

33°19'00"
117°37'30"

35'

1000

192

Prepared by the National Ocean Service, as part of a cooperative program with the Los Angeles District, U.S. Army Corps of Engineers. Compiled from registered historical shoreline surveys of the National Ocean Service, and registered to base maps furnished by the U.S. Geological Survey (USGS). The area of this map generally corresponds to the U.S.G.S. quadrangle of the same name. 1982 shoreline compiled from aerial photography taken 1982.

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Pu
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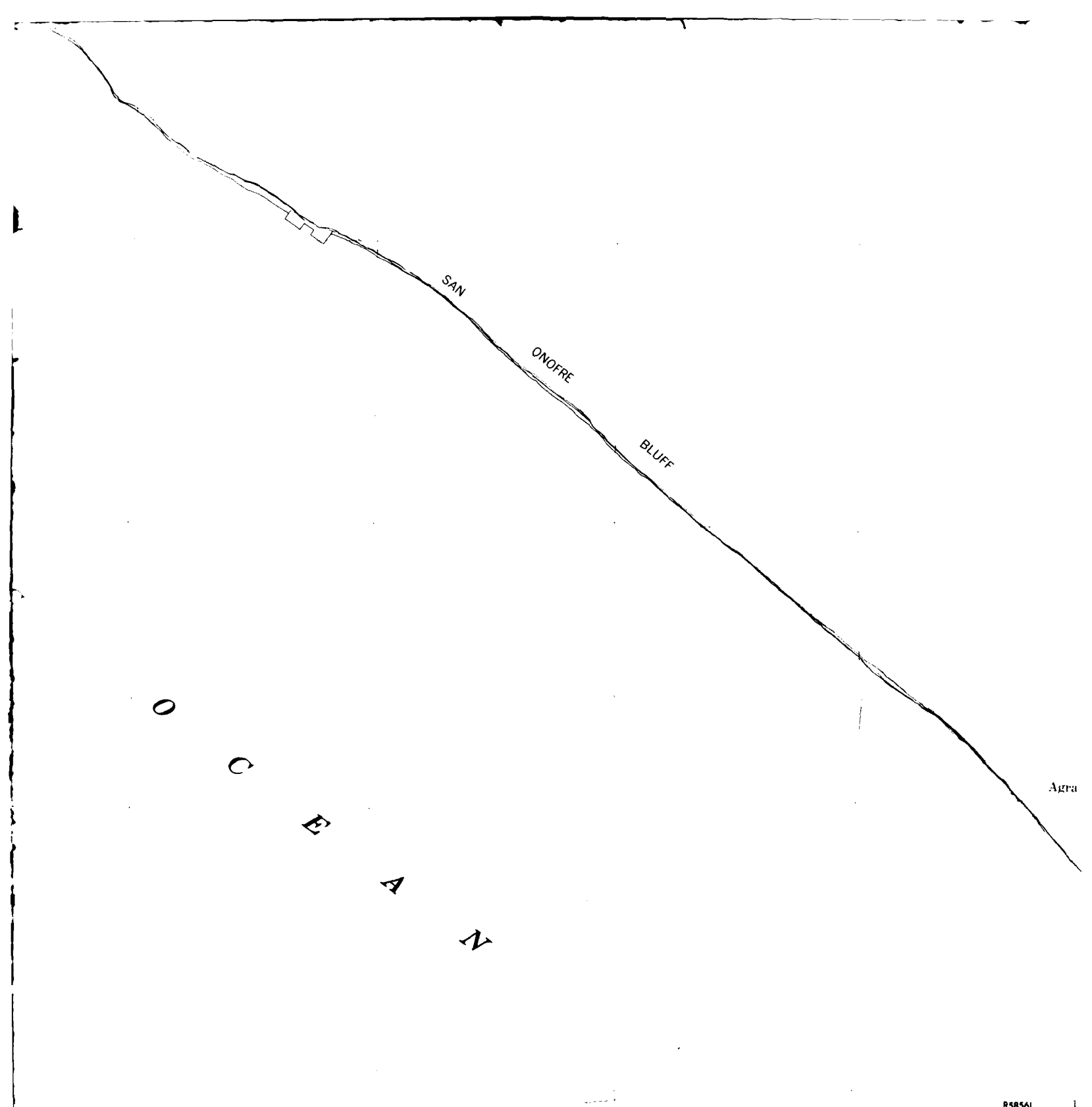
NATIONAL OCEANI
NAT



SCALE 1 24 000

0 1 MILE

1000 2000 3000 4000 5000 6000 7000 FEET

0 1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

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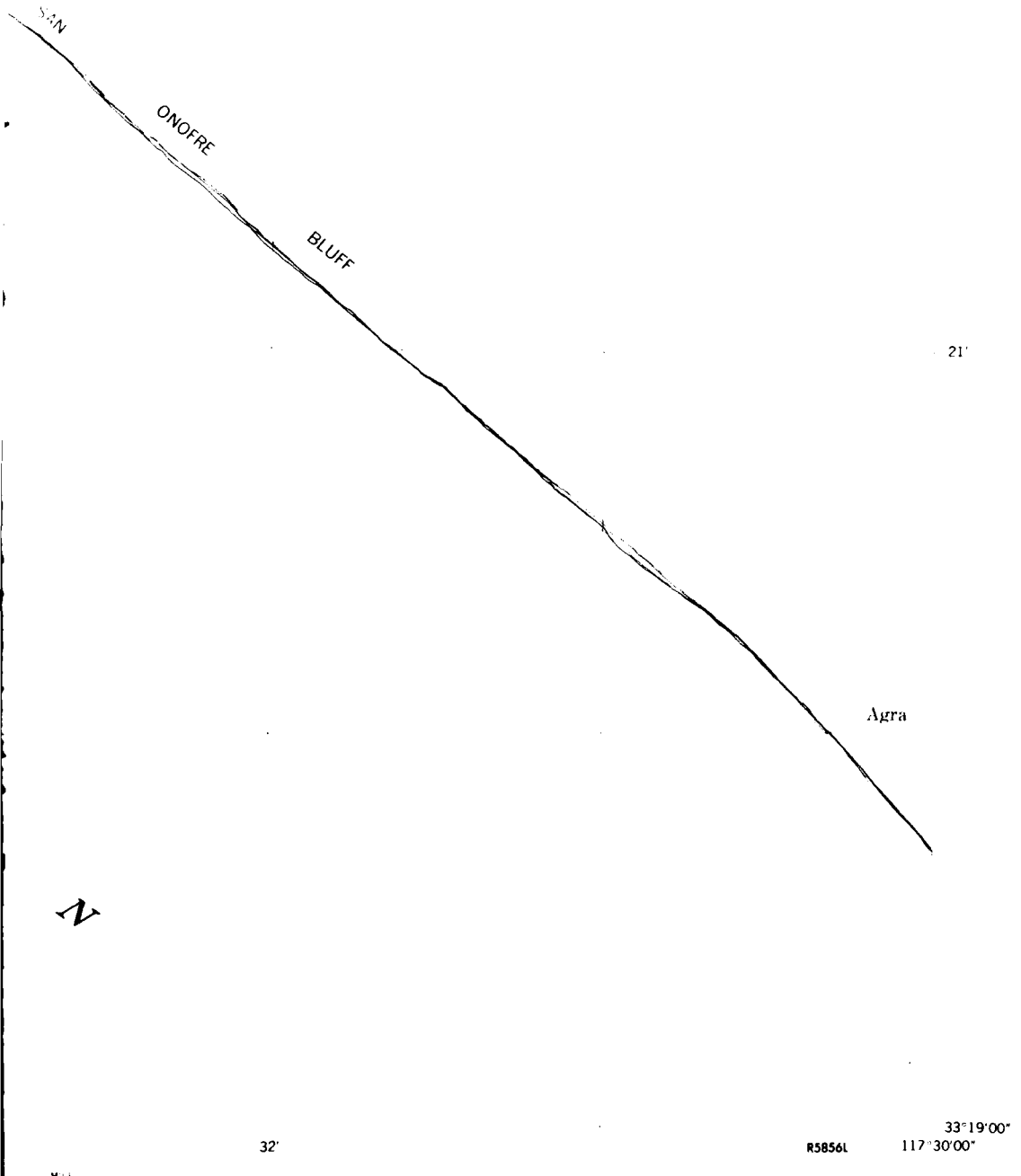
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

32'

R5856L

SAN ONOFRE BLUFF/SAN CLEMENTE, C/



SAN ONOFRE BLUFF/SAN CLEMENTE,CA.

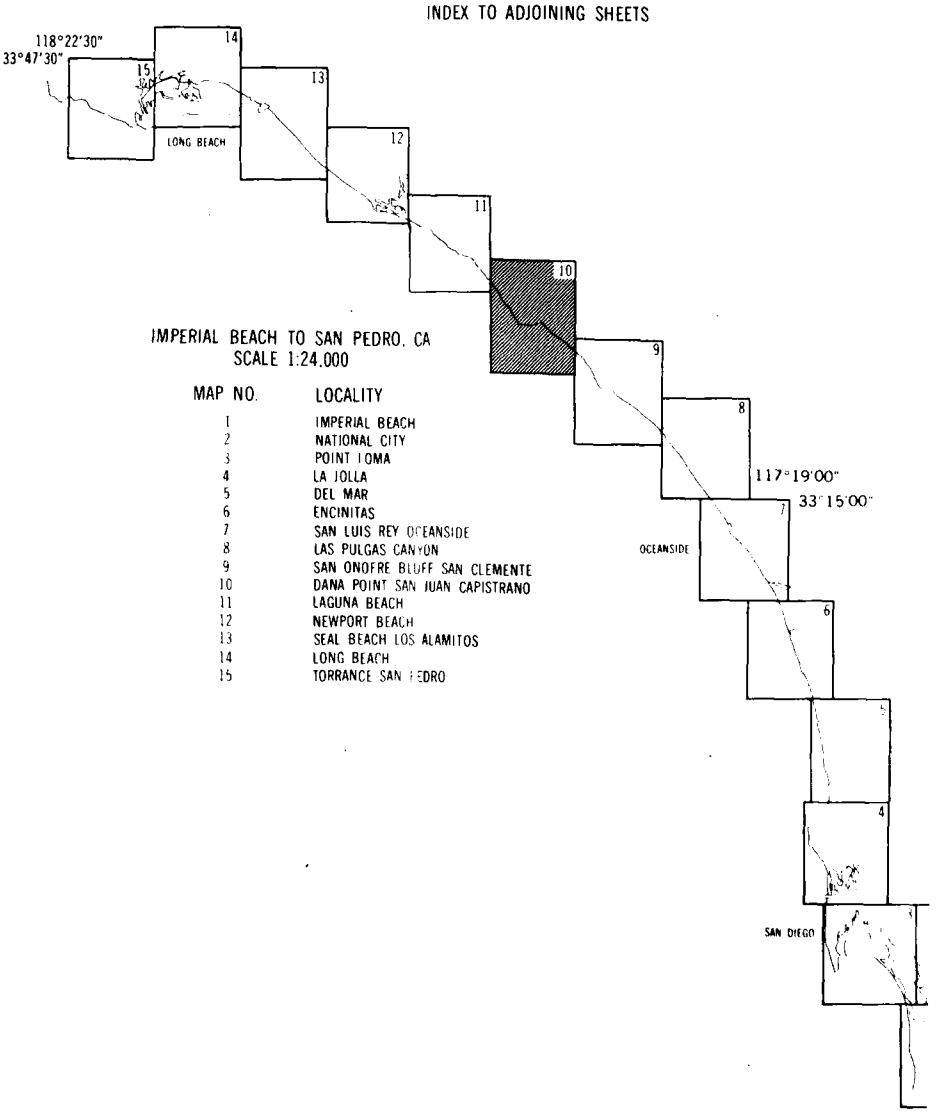
NOAA/NOS - CO
SHORELINE
Imperial Bea

117°45'00"
33°32'30"

43'

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

INDEX TO ADJOINING SHEETS



IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF SAN CLEMENTE
10	DANA POINT SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH LOS ALAMITOS
14	LONG BEACH
15	TORRANCE SAN PEDRO

South Laguna

30'

US Army Corps
of Engineers
Los Angeles District

/NOS - COE/LAD COOPERATIVE
ORELINE MOVEMENT STUDY
nperial Beach - San Pedro, CA

40'

117

USE OF SHORELINE MOVEMENT MAP

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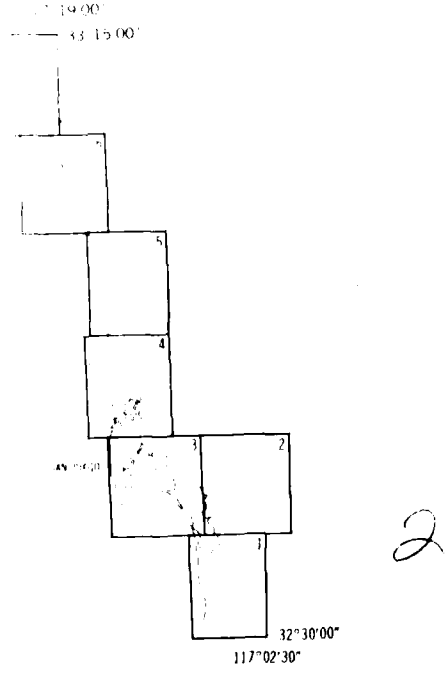
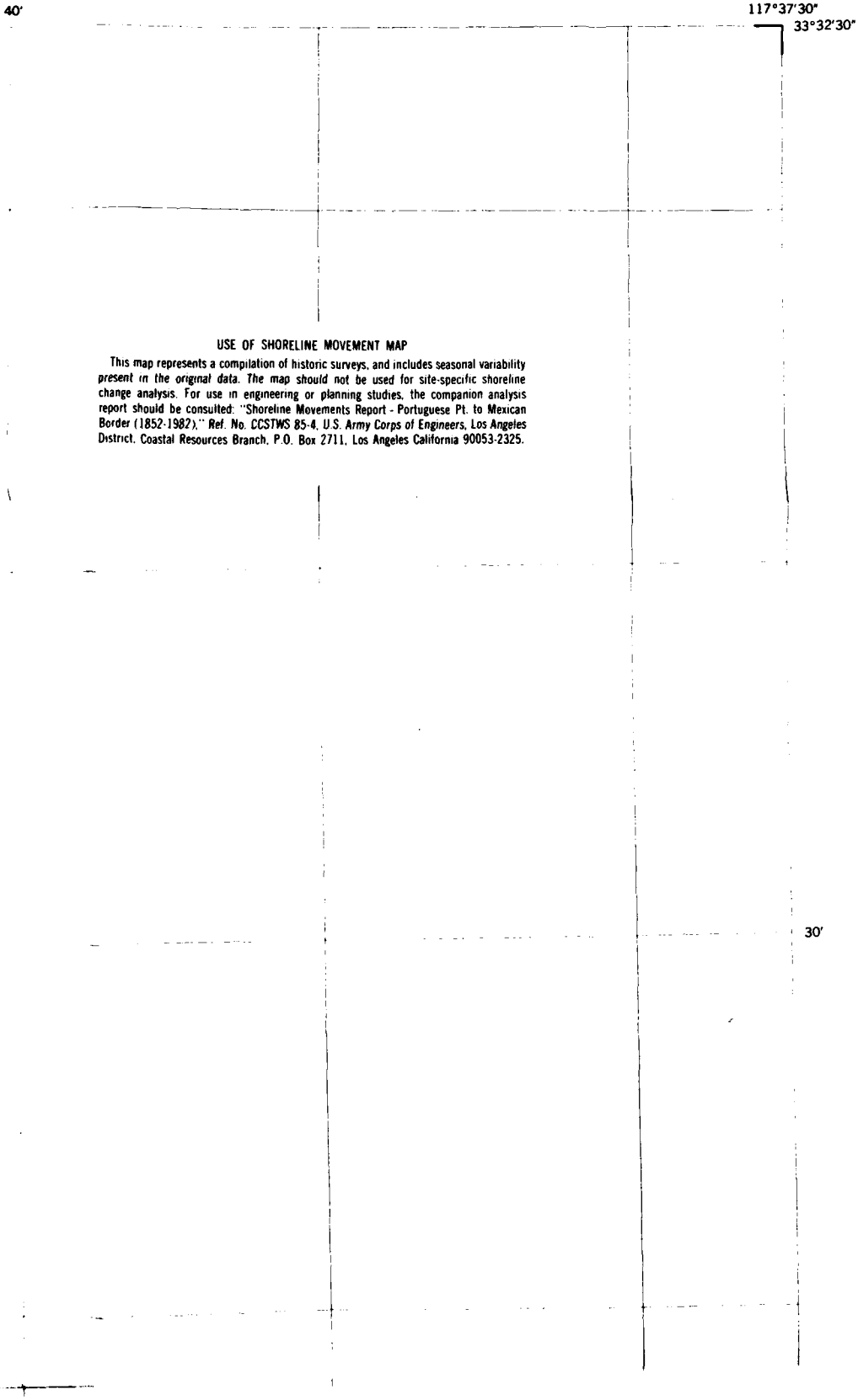


2

'E



USE OF SHORELINE MOVEMENT MAP

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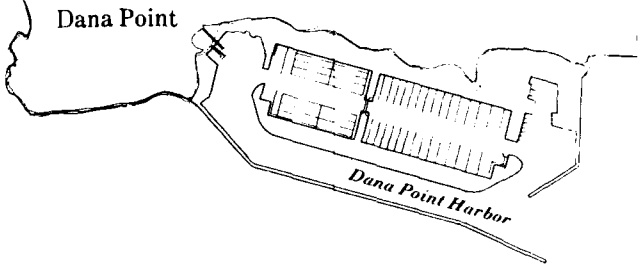
3

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1971/72 Field Survey
1959/60 Field Survey
1934 Field Survey



27'

PACIFIC OCEAN

33°25'00"
117°45'00"

43'

Prepared by the National Ocean Service, as part of a cooperative program with the Los Angeles District, U.S. Army Corps of Engineers. Compiled from registered historical shoreline surveys of the National Ocean Service, and registered to base maps furnished by the U.S. Geological Survey (USGS). The area of this map generally corresponds to the U.S.G.S. quadrangle of the same name. 1982 shoreline compiled from aerial photography taken 1982.

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SCALE 1:

1000 0 1000 2000

1927 NORTH AME
LAMBERT PR

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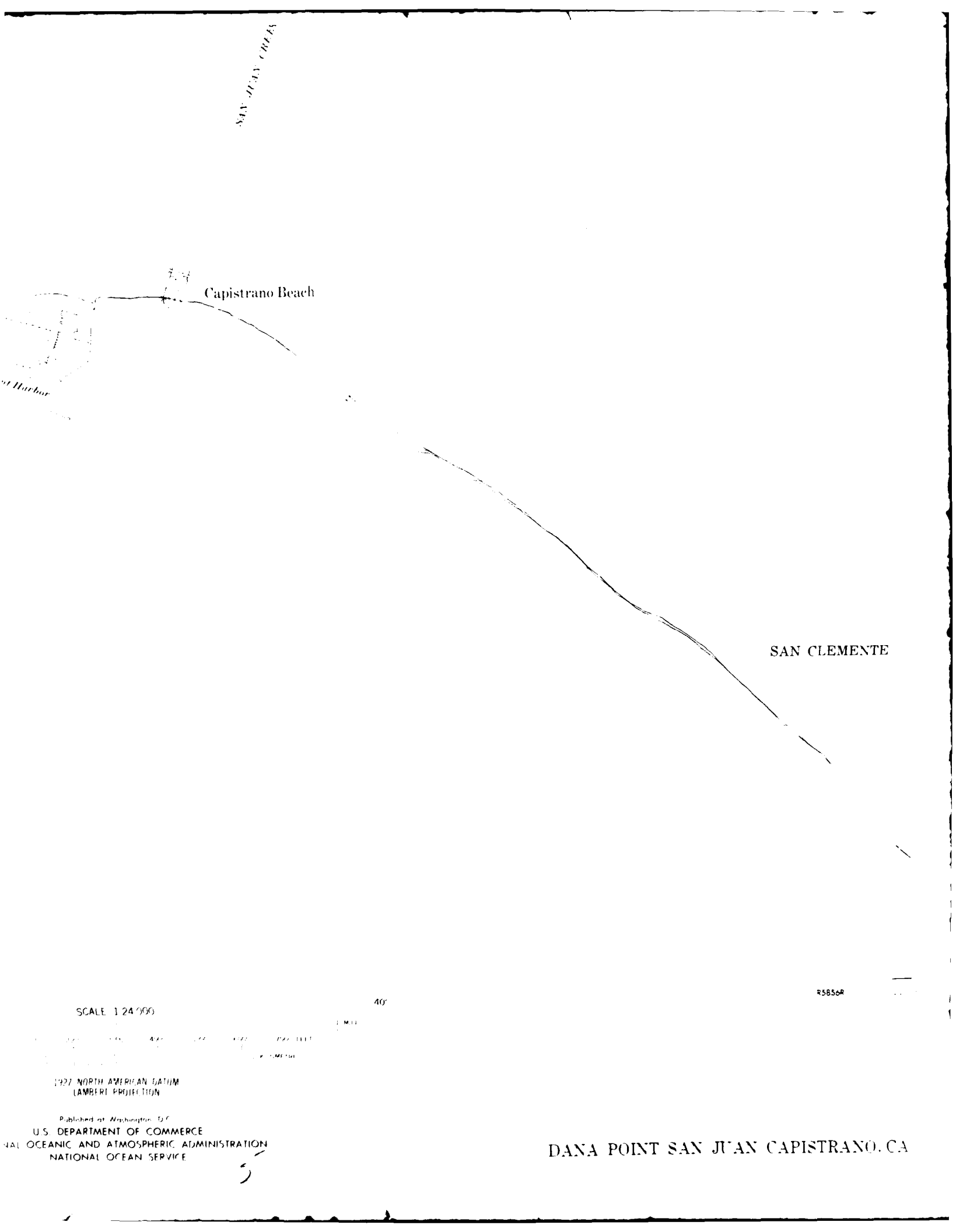
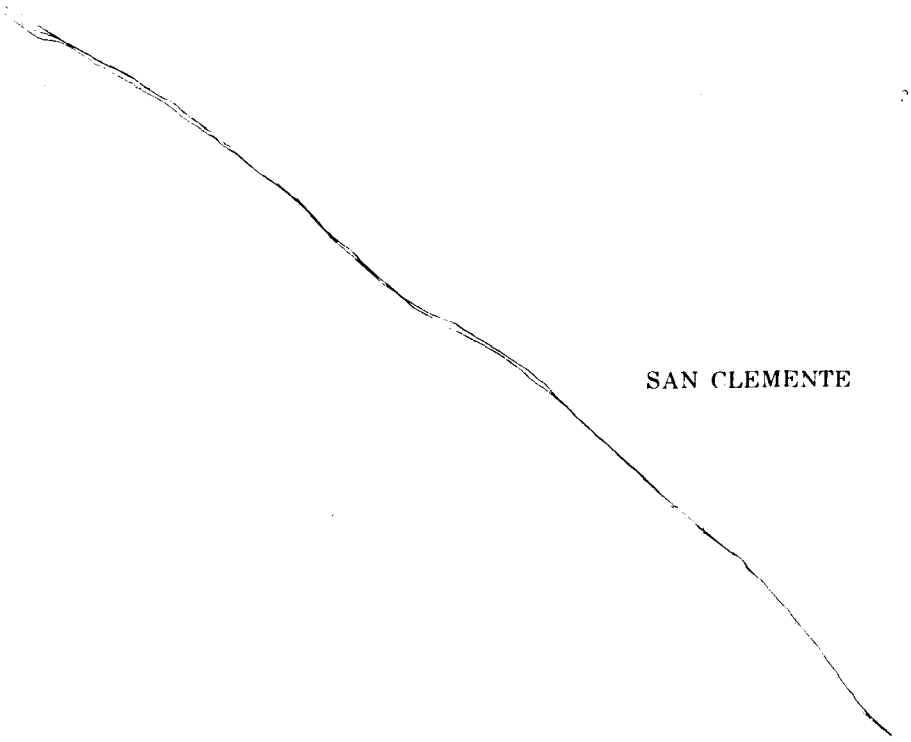
U.S. DEPARTMENT
NATIONAL OCEANIC AND ATA
NATIONAL OCI


SAN JUAN CREEK
Capistrano Beach
SAN CLEMENTE
R5856R
40°
SCALE 1:24 000
1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION
Published at Washington, D.C.
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
DANA POINT SAN JUAN CAPISTRANO, CA



33°25'00"
117°37'30"

R5856R

DANA POINT/SAN JUAN CAPISTRANO, CA.

6

NOAA/NOS - COE
SHORELINE M
Imperial Beac

117° 52'30"
33° 37'30"

50'

USE OF SHORELINE MOVEMENT MAP

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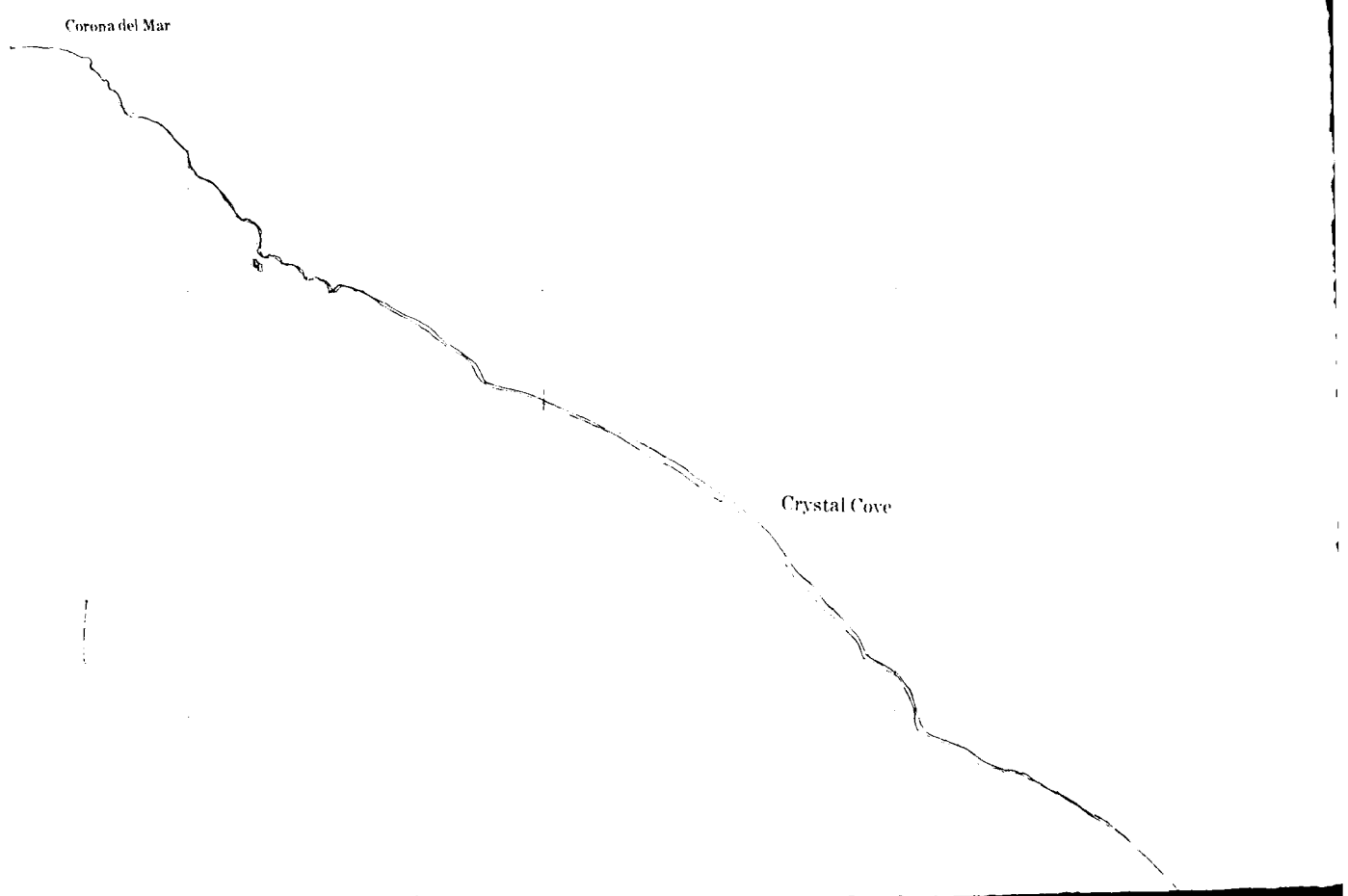

US Army Corps
of Engineers
Los Angeles District

AA/NOS - COE/LAD COOPERATIVE SHORELINE MOVEMENT STUDY

Imperial Beach - San Pedro, CA

47

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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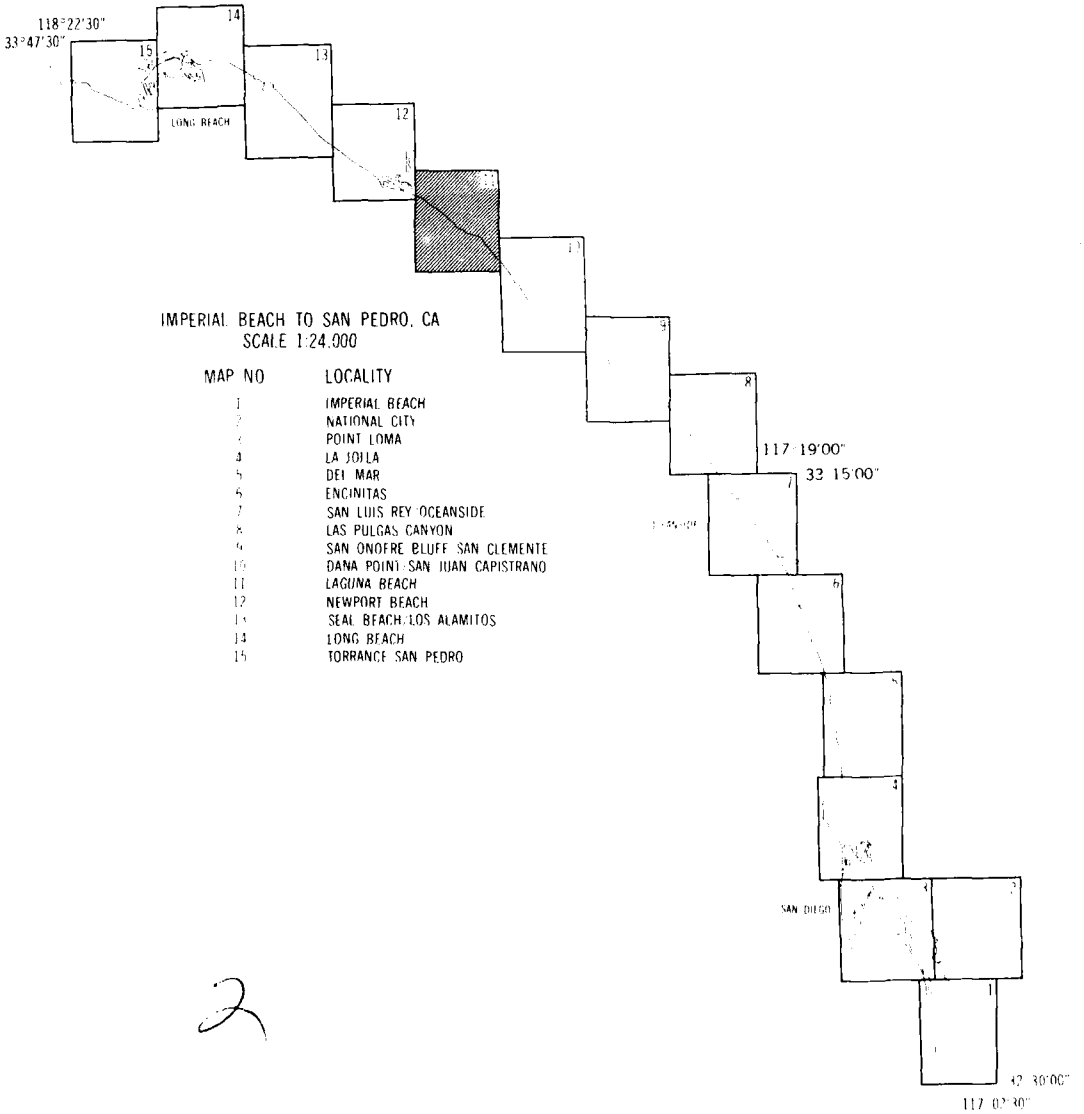


IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY-OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF-SAN CLEMENTE
10	DANA POINT-SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH-LOS ALAMITOS
14	LONG BEACH
15	TORRANCE-SAN PEDRO

2

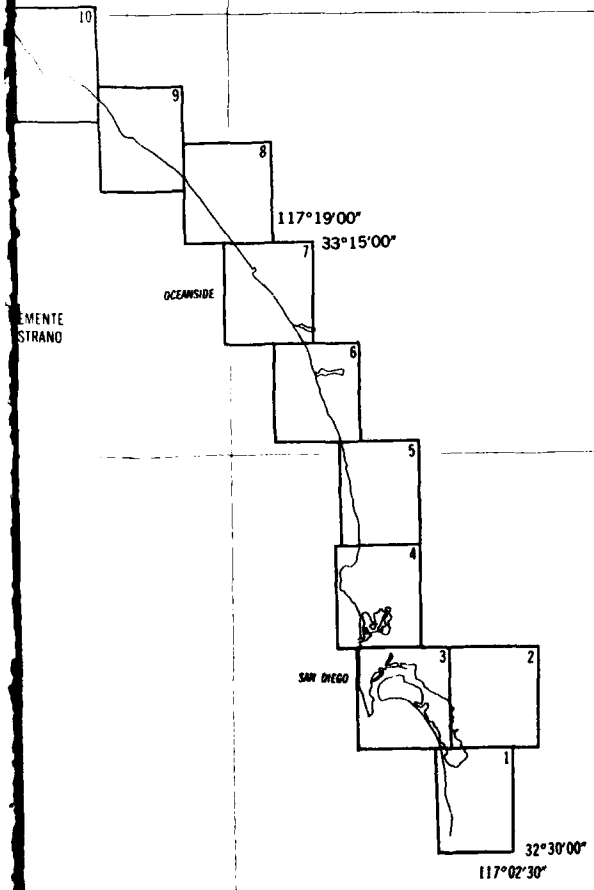
09

47'

117°45'00"
33°37'30"

ATIVE SHORELINE MOVEMENT
PPING PROGRAM

ADJOINING SHEETS



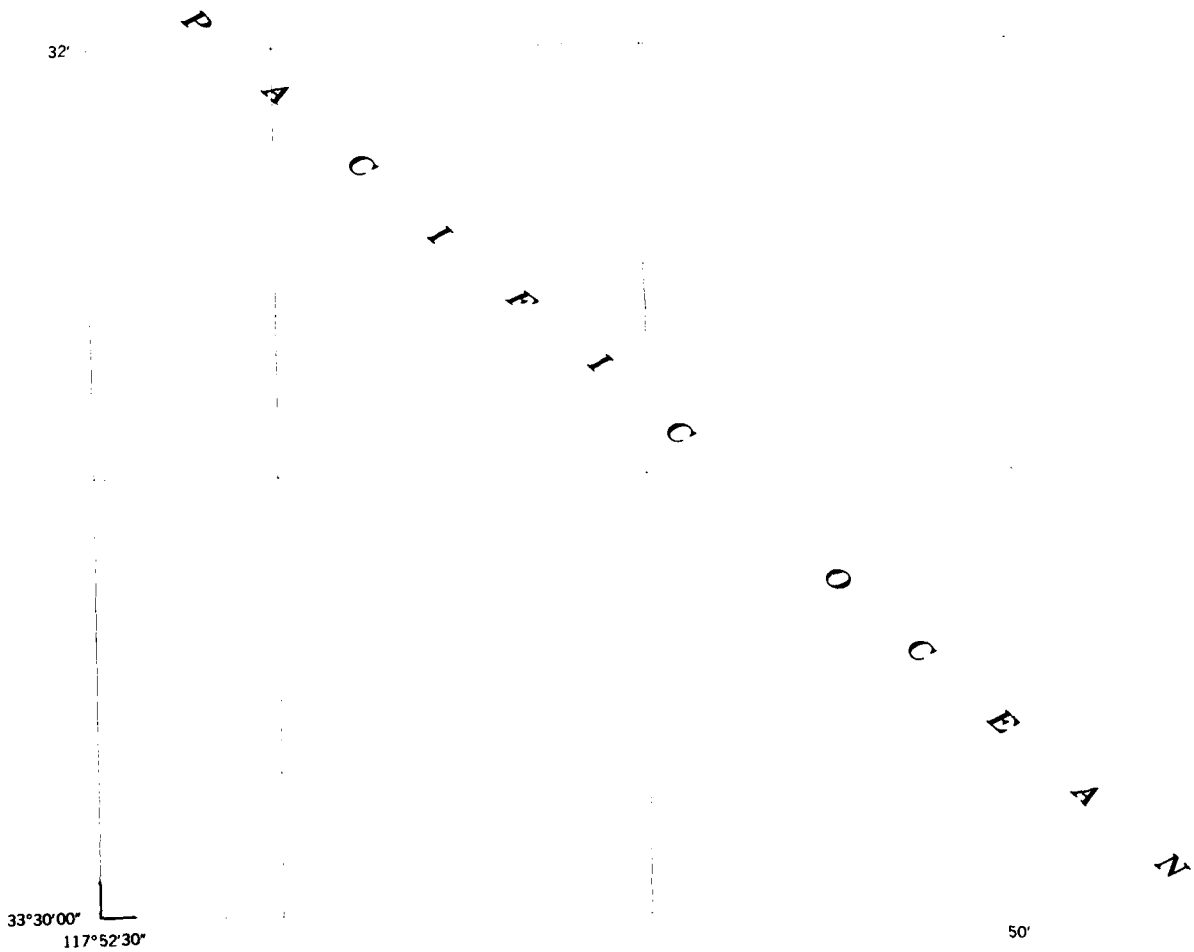
EMENTE
STRANO

35'

3

LEGEND
(Source of Mean High Water Line)

——— March 1982 NOS Aerial Photography
1971 Field Survey
1959 Field Survey
– – – – 1934 Field Survey
1926 Field Survey
1885 Field Survey
1875 Field Survey



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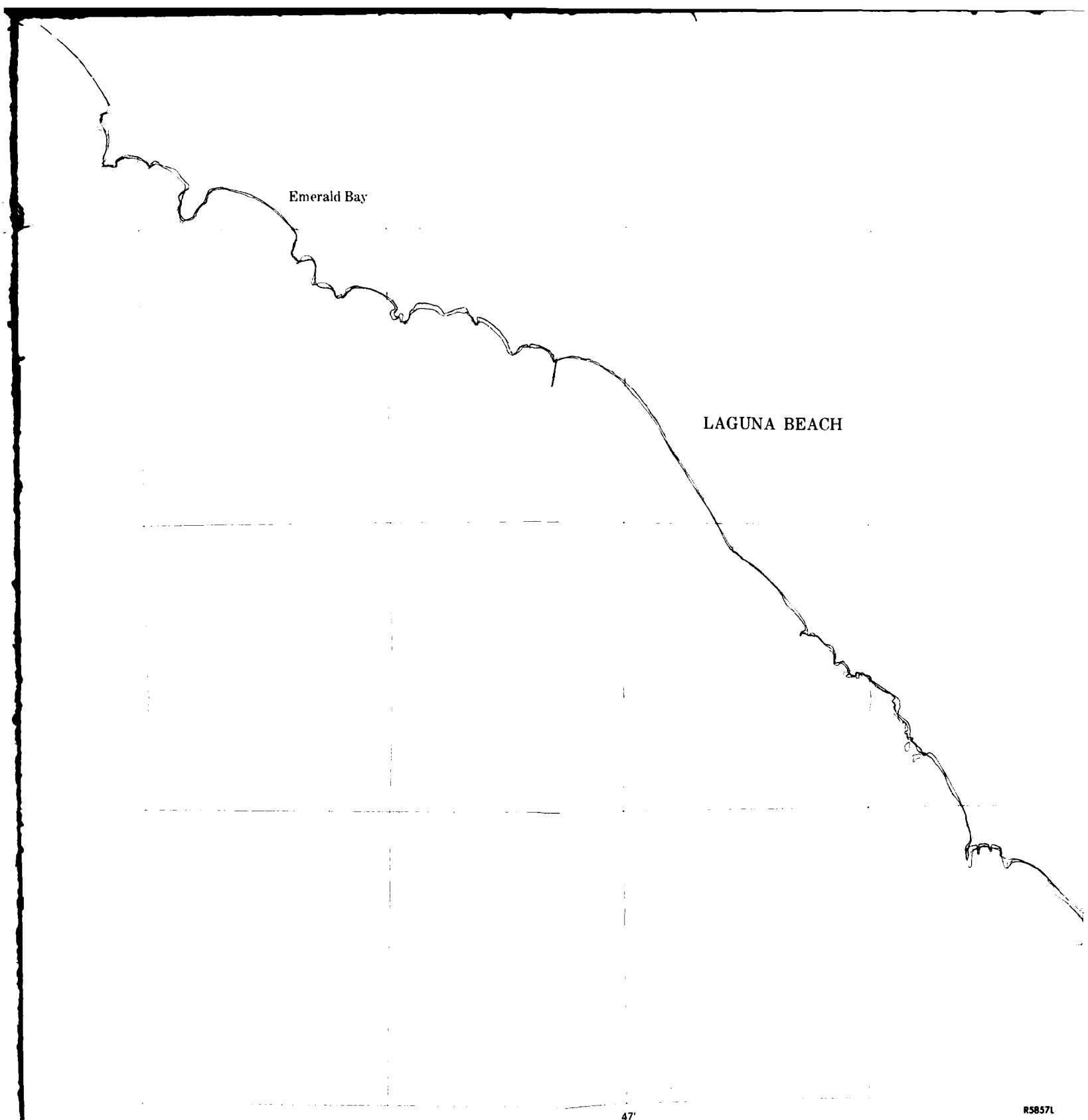
U.S.
NATIONAL OCE



R5857L

SCALE 1:24 000

0 1 MILE

1000 2000 3000 4000 5000 6000 7000 FEET

0 1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

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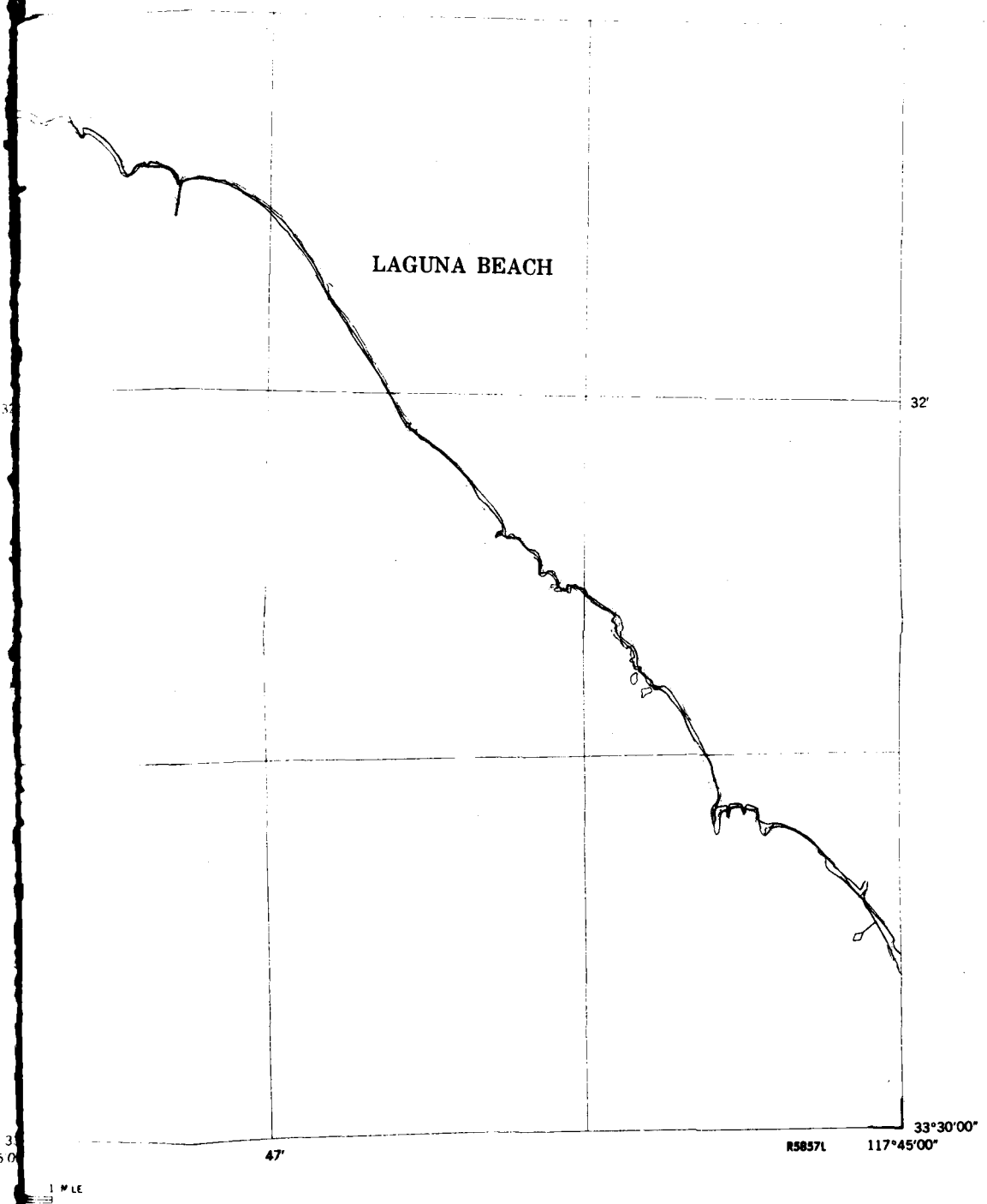
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

LAGUNA BEACH,

5



LAGUNA BEACH, CA.

6

NOAA/NOS - COE
SHORELINE M
Imperial Beac

118°00'00"
33°42'30"

58'

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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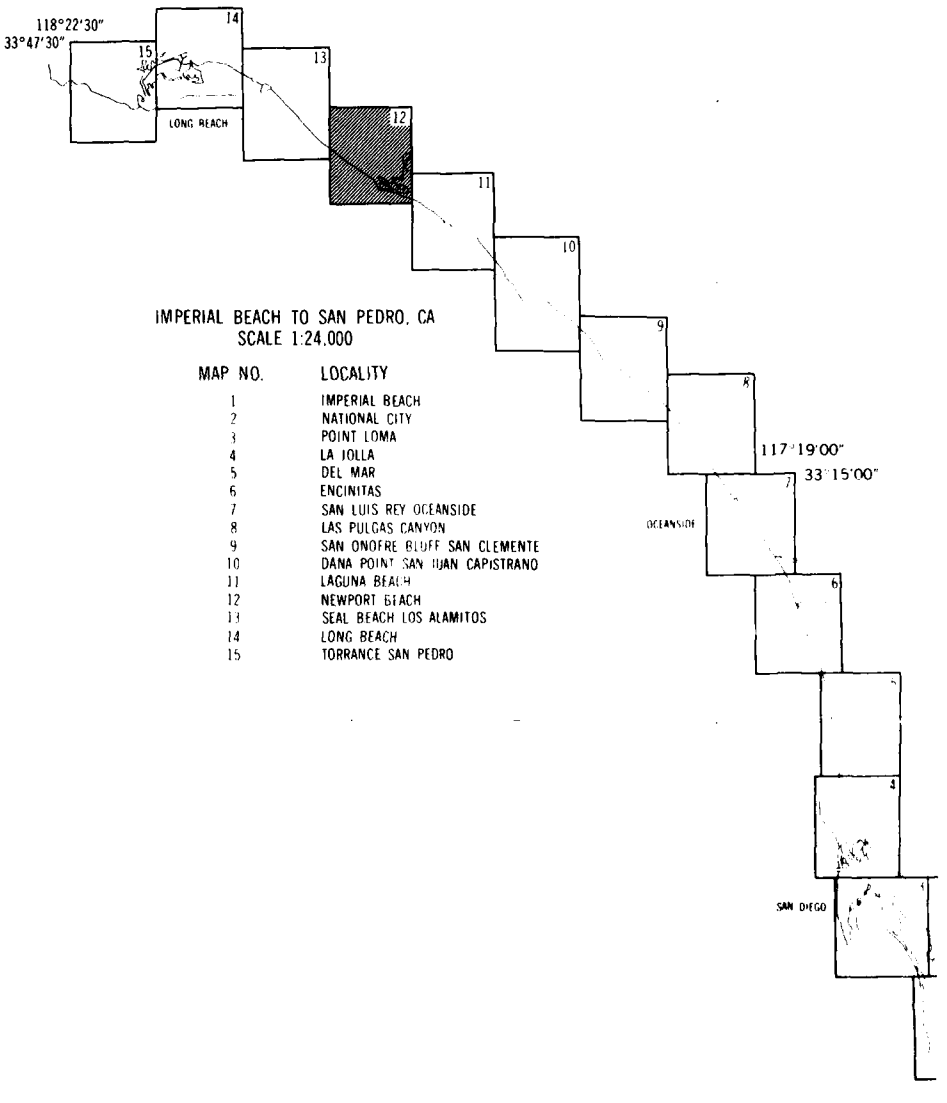

IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO.	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF SAN CLEMENTE
10	DANA POINT SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH LOS ALAMITOS
14	LONG BEACH
15	TORRANCE SAN PEDRO

40'

HUNTINGTON BEACH

US Army Corps
of Engineers
Los Angeles District

'NOS - COE/LAD COOPERATIVE
)RELINE MOVEMENT STUDY
perial Beach - San Pedro, CA

55'

117 [illegible]

USE OF SHORELINE MOVEMENT MAP

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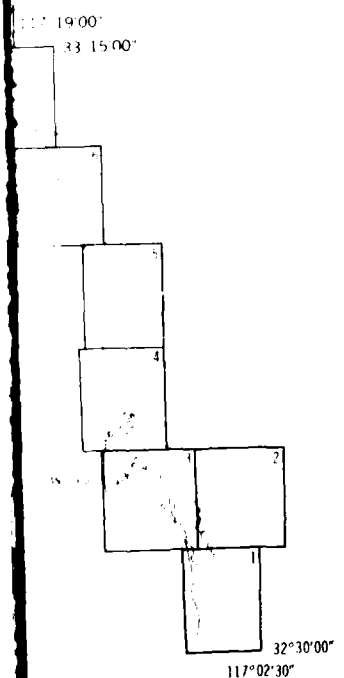

COSTA MESA

NEWPORT BAY

55'

117°52'30"

33°42'30"

USE OF SHORELINE MOVEMENT MAP

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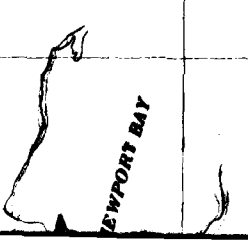
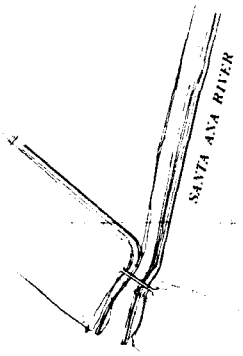
40

COSTA MESA





PACIFIC O

37'

LEGEND
(Source of Mean High Water Line)

March 1982 NOS Aerial Photography
1971 Field Survey
1959 Field Survey
1926 Field Survey
1874/75 Field Survey

33°35'00"
118°00'00"

58'

SCALE

1 1/2
1000 0 1000 2000
1 5

1927 NORTH
LAMBE

Published at
U.S. DEPARTME
NATIONAL OCEANIC AND
NATIONAL

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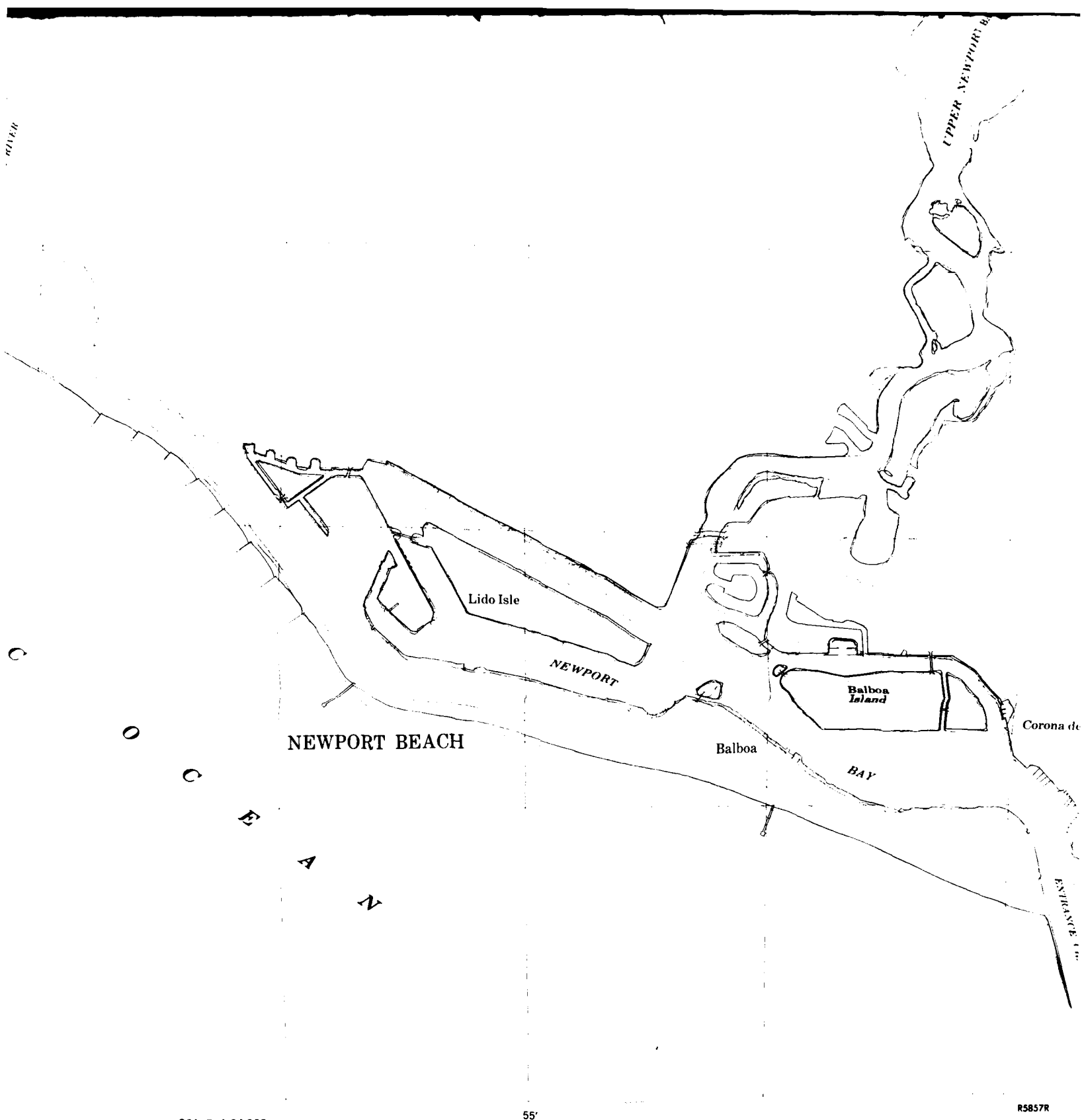
4



SCALE 1:24 000

1/2 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETRE

1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION

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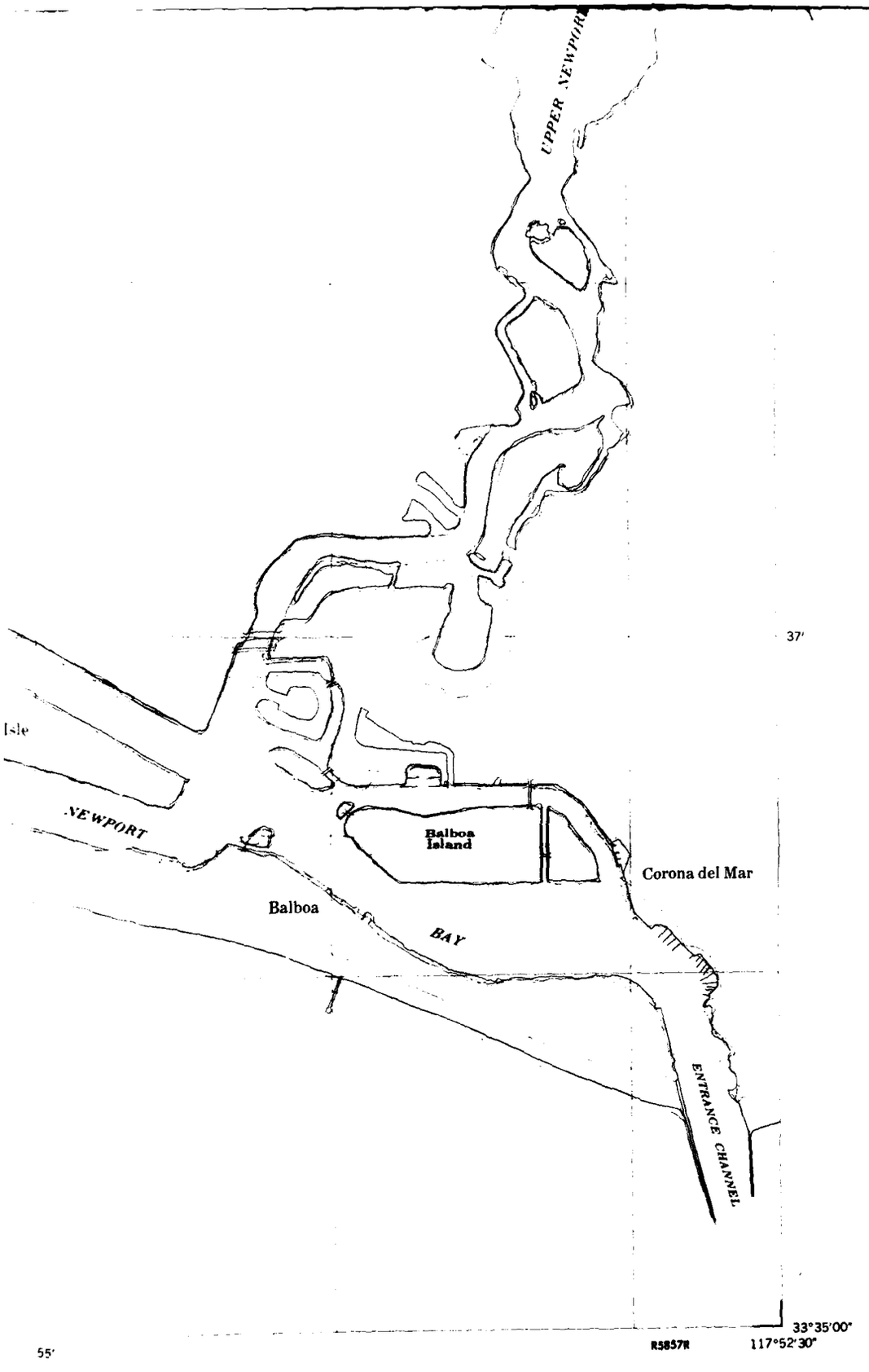
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

NEWPORT BEACH



NEWPORT BEACH, CA.

6

NOAA/NOS - COE/LA
SHORELINE MOV
Imperial Beach -

118°07'30"
33°46'00"

05'

USE OF SHORELINE MOVEMENT MAP

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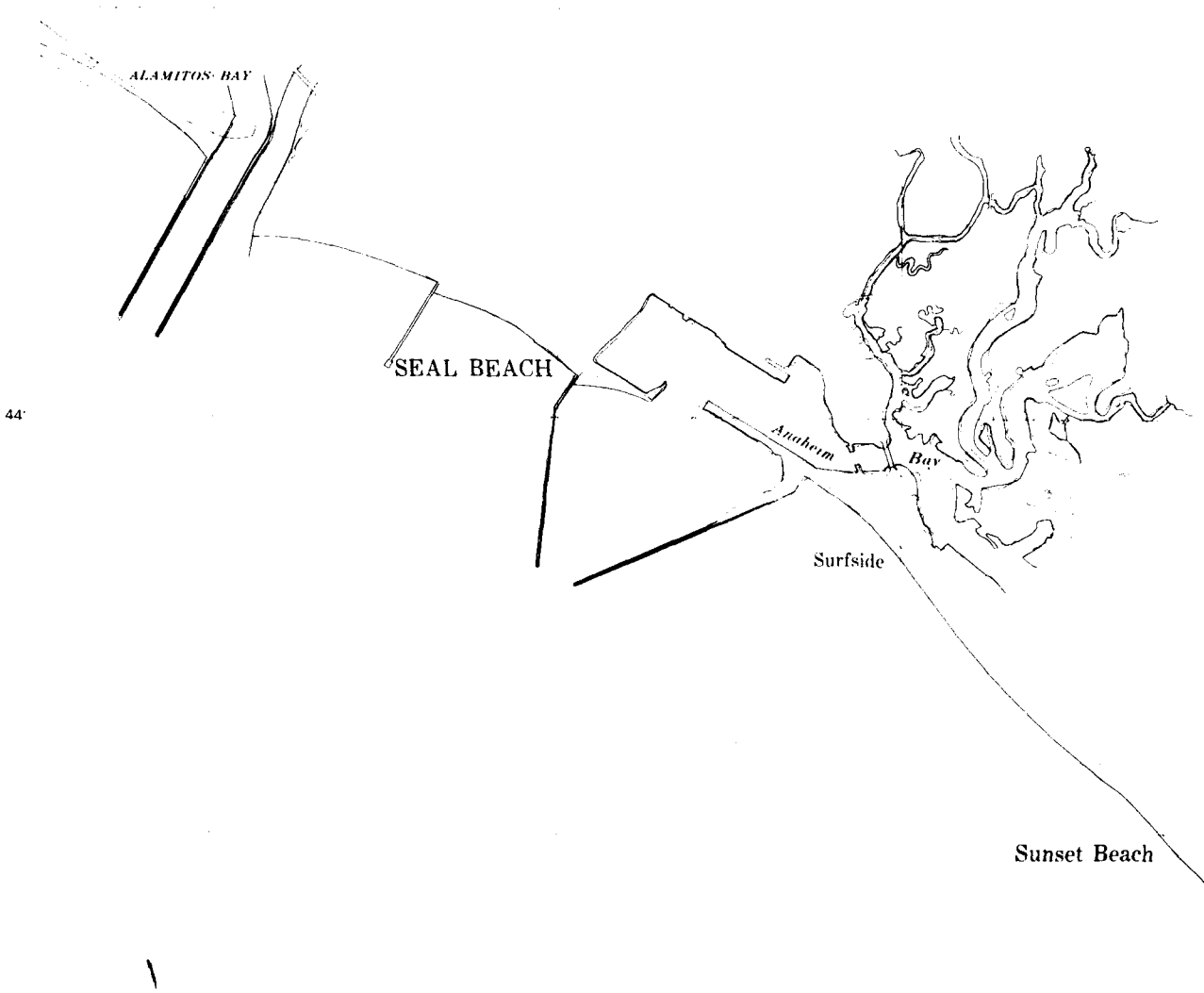

44'

US Army Corps
of Engineers
Los Angeles District

;OS - COE/LAD COOPERATIVE
RELINE MOVEMENT STUDY
perial Beach - San Pedro, CA

NOS - LAD COOPERATIVE SHORELINE MOVEMENT
MAPPING PROGRAM

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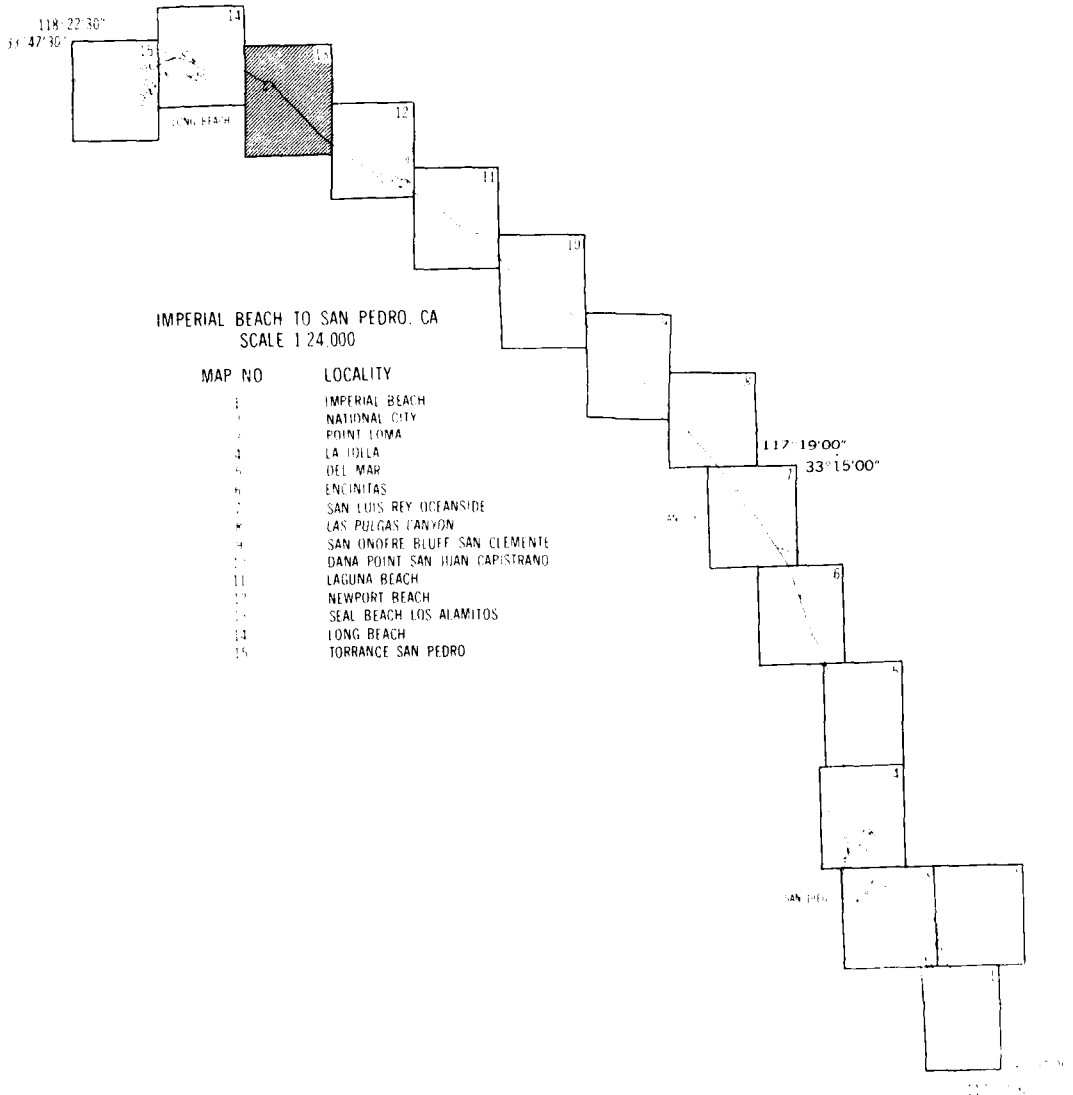


IMPERIAL BEACH TO SAN PEDRO, CA
SCALE 1:24,000

MAP NO	LOCALITY
1	IMPERIAL BEACH
2	NATIONAL CITY
3	POINT LOMA
4	LA JOLLA
5	DEL MAR
6	ENCINITAS
7	SAN LUIS REY OCEANSIDE
8	LAS PULGAS CANYON
9	SAN ONOFRE BLUFF SAN CLEMENTE
10	DANA POINT SAN JUAN CAPISTRANO
11	LAGUNA BEACH
12	NEWPORT BEACH
13	SEAL BEACH LOS ALAMITOS
14	LONG BEACH
15	TORRANCE SAN PEDRO

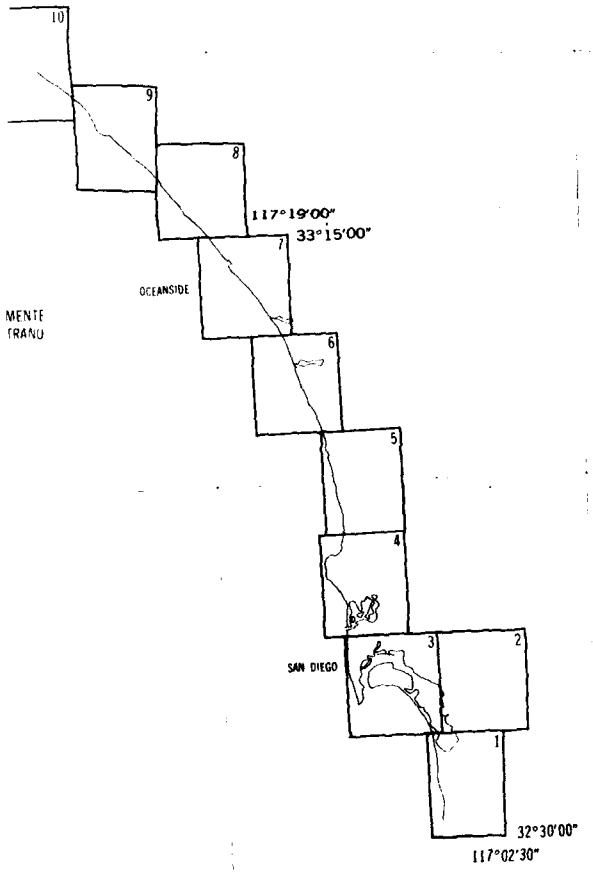
Beach

02'

118°00'00"
33°46'00"

VE SHORELINE MOVEMENT
G PROGRAM

)OINING SHEETS



MENTE
TRANO

44'

3

PACIFIC OCEAN

41'

LEGEND
(Source of Mean High Water Line)

——— March 1982 NOS Aerial Photography
1971/72 Field Survey
1959 Field Survey
——— 1920 Field Survey
1873/74 Field Survey

33°38'30"
118°07'30"

05'

1 1/2
1000 0
1

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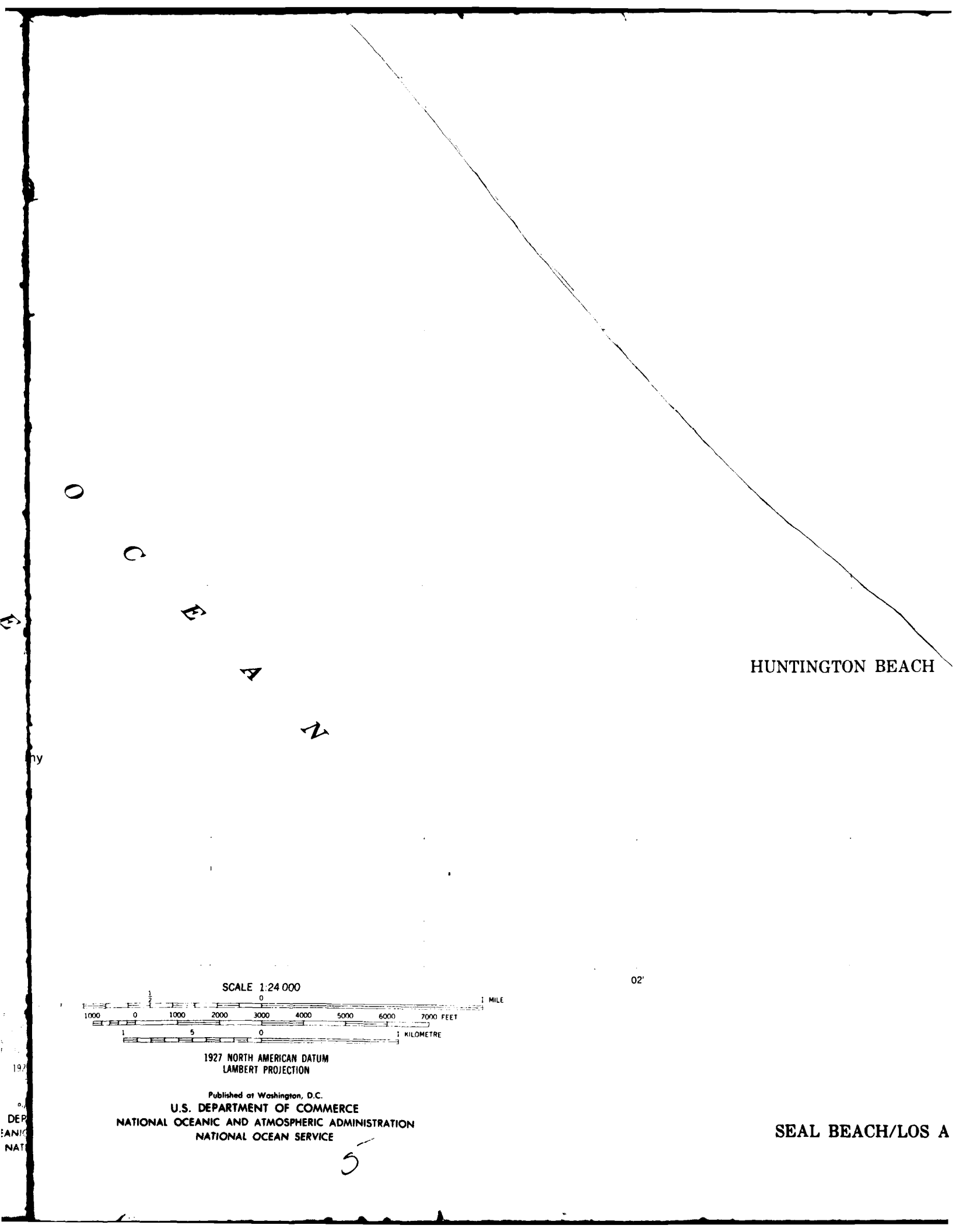
4

NATION


O C E A N
HUNTINGTON BEACH
02'
SCALE 1:24 000
1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
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1927 NORTH AMERICAN DATUM
LAMBERT PROJECTION
Published at Washington, D.C.
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
SEAL BEACH/LOS A
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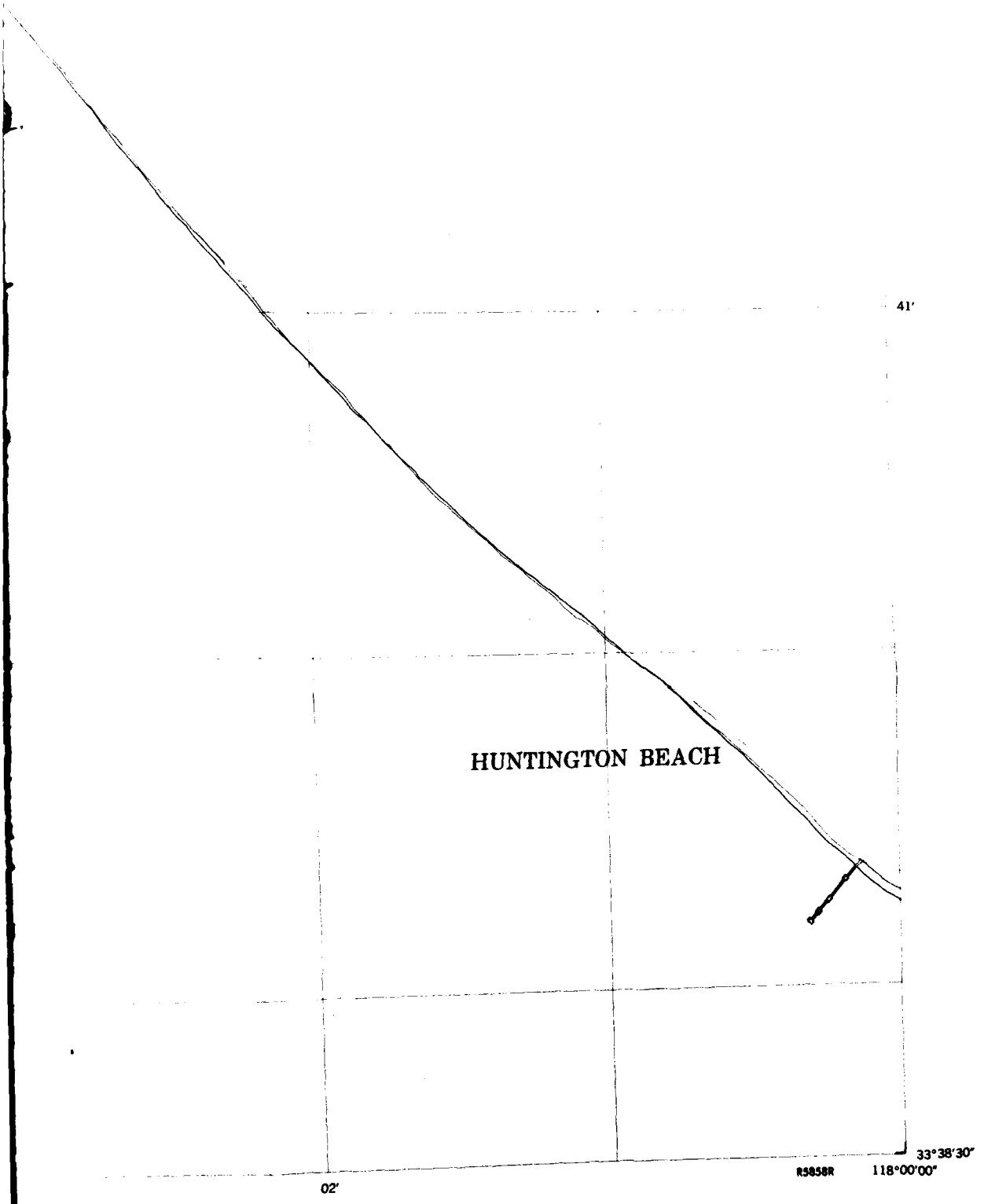

SEAL BEACH/LOS ALAMITOS, CA.

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